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THE ENGINEERING DRAUGHTSMAN

THE ENGINEERING DRAUGHTSMAN

BY

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AUTHOR OF "ELEMENTS OF ENGINEERING DRAWING"

WITH 96 FULL PLATE ILLUSTRATIONS AND OVER 150 EXAMPLES

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PREFACE

THIS book is intended for the use of students who are already familiar with the Elementary Principles of Engineering Drawing. The examples provided call for the practical application of these principles in the production of "working" drawings, and an attempt is made to provide for students a course of work comparable to that of a draughtsman during his apprenticeship.

The work of the average junior draughtsman varies, of course, very considerably in different classes of work and in different offices, but may be fairly summed up as follows :—

(1) Making working drawings of details from information obtained from general arrangement drawings.

(2) Making assembly or arrangement drawings from detailed working drawings.

(3) Making working drawings of details of new machines similar to machines previously made, but with modifications in both size and shape.

(4) Making working drawings from dimensioned sketches taken from actual machine details.

(5) Making working drawings to verbal instructions and hand sketches, and

(6) Tracing.

In the following pages there are numerous examples covering cases 1, 2, 3, and 6. Case 4 is easily provided for by the use of models and actual machine parts, the latter being distinctly preferred. An instructor who has had some practical experience should have little difficulty in providing for Case 5. It will thus be possible to arrange that a student's work runs on parallel lines with that of the apprentice draughtsman.

The practice of specialising in any one particular branch of engineering in the *early stages* of a student's career should not be encouraged. The essential foundation work of all engineering drawing is the same, whichever branch may be

finally selected for specialisation, and specialisation may fittingly come towards the end of a student's course. In the meantime his drawing office work should include, as his other work does, as many branches of engineering as possible.

The collection of examples given in this book makes it possible to provide a course of work which will give the student a comparatively wide experience.

A perusal of the List of Plates will reveal the scope and variety of the work provided. In many cases sufficient information is given to enable students to make sets of working drawings of complete machines, and the natural preference to deal with a machine in its entirety rather than with some isolated part of it is thus catered for. Amongst such complete machines that are included may be mentioned a steam hammer, a hydraulic capstan, a single ram pump, a hydraulic press, an air pump, an oil pump, a steam engine governor, and a lathe.

It is not intended that the plates shall be capable of interpretation without the aid of the text. Indeed, the description lists, which largely monoplise the space usually devoted to text, should be considered as integral parts of the instruction sheets and should similarly form an integral part of every working drawing.

The method of indicating the various materials by the use of different kinds of section lining has not been adopted in making the illustrations, nor is it recommended in the making of working drawings. An infinitely safer plan is to definitely specify in the description list the particular material required.

Many of the plates are perhaps somewhat disfigured by the lavish use of reference letters and numbers, but since these references render the plates easier of interpretation it was considered desirable to sacrifice appearance for utility.

In a large majority of cases the text describing any particular plate will be found on the page facing the plate, thus obviating the necessity of turning over leaves for purposes of reference. Owing to the length of the description lists in a few cases the accompanying text occupies an additional following page.

The book has been divided into sections for convenience of reference, but it is not intended that the examples should be worked in their numerical order. Instructors naturally prefer to plan their own courses for their students, but for students working privately the alternative courses outlined on page xii will be found serviceable.

By the kind permission of the British Engineering Standards Committee, tables concerning standard bolts and nuts, screw threads and keys are included towards the end of the book,

together with tables of wire gauges, decimal and millimetre equivalents, and weights of materials.

The author's thanks are also due to Professor Unwin, LL.D., F.R.S., for the privilege of including his methods for determining approximate involute and cycloidal shapes of gear-wheel teeth. To his esteemed colleagues, Messrs. H. M. Edmonds, Esq., B.Sc., J. Beaumont Shaw, Esq., A.R.C.S., Wh.Ex., A. T. Dover, Esq., A.M.I.E.E., and H. L. Dingwall, Esq., the writer is greatly indebted for helpful criticism and suggestions, and takes this opportunity to express his gratitude for their services. Especially does the author realise how much he owes to the conscientious labours of Mr. Edmonds, and it is not too much to say that whatever measure of immunity from error the book may possess is largely attributable to the meticulous care exercised by Mr. Edmonds in his checking of the drawings from which the blocks were made. Finally the author would place on record his gratitude to all the engineering firms who so generously supplied prints of their working drawings, by the aid of which he was able to make the illustrations. A list of these firms will be found on the following page.

E. R.

BATTERSEA POLYTECHNIC
May, 1919

The following is a list of the engineering firms to whom the author is indebted for the supply of working drawings.

Messrs. Thomas Beeley & Son, Ltd., Hyde, Manchester.
" Belliss & Morcom, Ltd., Birmingham.
" Beyer Peacock & Co., Ltd., Manchester.
" The Brush Electrical Engineering Co., Ltd., Loughborough, Leicestershire.
" Crofts Ltd., Bradford, Yorks.
" Davidson & Co., Ltd., Belfast.
" The Gnome & Le Rhone Engine Co., Ltd., London, E. 17.
" Humber Ltd., Coventry.
" Maiden & Co., Ltd., Tool Makers, Hyde.
" Marshall Sons & Co., Ltd., Gainsborough.
" B. & S. Massey, Ltd., Openshaw, Manchester.
" Musgrave Bros., Leeds.
" The Newall Engineering Co., Ltd., London, E. 17.
" Ruston Proctor & Co., Ltd., Lincoln.
" The Skefko Ball Bearing Co., Ltd., Luton.
" R. A. Skelton & Co., Moorfields, London.
" South-Eastern and Chatham Railway Co. (per James Clayton, Esq.).
" Tangyes Ltd., Birmingham.
" Turbine Gears, Ltd., Hyde.
" Turner, Atherton & Co., Ltd., Denton, Manchester.
" The Unbreakable Pulley and Mill Gearing Co., Ltd., Manchester.
" The Vaughan Crane Co., Ltd., Openshaw, Manchester.

LIST OF PLATES

PLATE PAGE

INTRODUCTION.

1. Specimen Working Drawing . xx
2. Specimen Working Drawing . xxii

SECTION I.

GENERAL ENGINEERING.

3. Flexible Coupling for Shafts . 2
4. Benn Patent Friction Clutch . 4
5. Head Gear Pulley for Mine Shaft 8
6. Housing for Sirocco Fan . . 10
7. Bearing for Mine Ventilating Fan 12
8. Hanger Bracket with Ball-bearing 14
9. Pedestal Thrust-bearing . . 16
10. Block for 10-ton Crane . . 18
11. Spring Relieving Block for 40-ton Crane 20
12. Steel Stanchion 24

SECTION II.

TOOTHED GEARING.

13. Cycloidal Curves and Teeth . 30
14. Involute Curves and Teeth . 34
15. Types of Gear Wheels . . 36
16. Internal Spur Gearing . . 38
17. Bevel Gearing 40
18. Helical Gearing 42
19. Worm Gearing 44
20. Worm Gearing Housing . . 46

SECTION III.

DETAILS OF LOCOMOTIVES AND OTHER STEAM ENGINES.

21. Locomotive Valve Rod Guide . 50
22. Locomotive Cross-head (Two Bar) 54
23. Locomotive Cross-head (Single Bar) 56
24. Locomotive Cylinder Cover (Metallic Packing) 58

PLATE PAGE

25. Locomotive Steam Regulator . 60
26. H.S. Steam Engine Connecting Rod 62
27. H.S. Steam Engine Eccentric and Rod 64
28. Traction Engine Cylinders . 66
29. Traction Engine Valves and Pistons 68
30. Traction Engine Cylinder Covers 70
31. Traction Engine Cylinder Covers 72
32. Pickering Governor . . . 74
33. Pickering Governor . . . 76
34. Pickering Governor . . . 78
35. Turbine Governor . . . 80
36. Turbine Governor . . . 82

SECTION IV.

STEAM BOILERS AND MOUNTINGS.

37. 5″ Steam Stop Valve . . . 86
38. Scum Cock for Locomotive Boiler 88
39. Ramsbottom Safety Valves . 90
40. Traction Engine Firebox . . 92
41. Marine Type Boiler . . . 94
42. Suckling Water Tube Boiler . 98
43. Suckling Water Tube Boiler Details 100

SECTION V.

DETAILS OF AEROPLANE ENGINES AND MOTOR VEHICLES.

44. Aeroplane Propeller Hub . . 104
45. Cylinder, etc., for Gnome Engine 106
46. Air Pump for Gnome Engine . 108
47. Oil Pump for Gnome Engine . 112
48. Cone Clutch for Motor Car . 116
49. Gear Box for Motor Car . . 120
50. Steering Gear for Motor Omnibus 124

PLATE PAGE

SECTION VI.

ELECTRICAL ENGINEERING.

51. Field Magnet (C.C. Generator) . 128
52. Armature (C.C. Generator) . 132
53. Commutator (C.C. Generator) . 134
54. Pedestal Bearing (C.C. Generator) 136
55. Brush Holder (C.C. Generator) . 138
56. Stator (Induction Motor) . . 140
57. Rotor, Slip Rings, etc. (Induction Motor) 142
58. End Frame and Bearing (Induction Motor) 144
59. Brush Holder (Induction Motor) 146

SECTION VII.

HYDRAULIC ENGINEERING.

60. Hydraulic Stop Valve . . 150
61. Hydraulic Press, Details . . 152
62. Hydraulic Press, Details . 154
63. Single Ram Pump, Details . 156
64. Single Ram Pump, Details . 158
65. Hydraulic Capstan, Arrangement 160
66. Hydraulic Capstan, Bedplate . 162
67. Hydraulic Capstan, Revolving Plate 164
68. Hydraulic Capstan, Crank Shaft, etc. 166
69. Hydraulic Capstan, Cylinders, etc. 168
70. Hydraulic Capstan, Valves . 170
71. Hydraulic Capstan, Valves and Unions 172

SECTION VIII.

MACHINE TOOLS AND JIGS.

72. Shell-ending Lathe, Arrangement 176
73. Shell-ending Lathe, Stand, etc. 178
74. Shell-ending Lathe, Bed . . 180
75. Shell-ending Lathe, Saddle . 182
76. Shell-ending Lathe, Spindle, etc. 184
77. Square Turret for Lathe . . 186
78. Pipe-screwing Machine, Arrangement 188
79. Pipe-screwing Machine, Bed . 190
80. Pipe-screwing Machine, Swivel Saddle Details . . . 192
81. Pipe-screwing Machine, Swivel Saddle Details . . . 194
82. Pipe-screwing Machine, Swivel Saddle Arrangement . . 196
83. Pipe-screwing Machine, Turning Head 198
84. Pipe-screwing Machine, Tool Holder 200
85. Pipe-screwing Machine, Leading Screw 202
86. Pipe-screwing Machine, Driving Gear 204
87. Pipe-screwing Machine, Stands, etc. 206
88. Drilling Jig 208
89. Drilling Jig 210

SECTION IX.

1 CWT. STEAM HAMMER.

90. Base Plate 216
91. Standards 218
92. Cylinders and Valves . . 220
93. Actuating Gear Details . . 224
94. Foot Gear 226
95. Actuating Gear Arrangement . 228
96. Foundation 230

LIST OF TABLES

	PAGE
British Standard Bolts, Nuts, and Screw Threads	232
,, ,, Fine Screw Threads	233
,, ,, Pipe Threads	233
Sellers', Metric, and B.A. Screw Threads	234
British Standard Keys	235
Weights of Materials	235
Imperial Standard Wire Gauge	236
Birmingham Wire Gauge	236
Decimal Equivalents of Fractional Parts of an Inch	237
Metrical Table with English Equivalents	237

SUGGESTED COURSES OF WORK

THE arrangement of examples given below provides a varied programme of work, detailing, assembling, modification of design, and tracing examples alternating with each other, the examples being taken from all sections of the book. As far as possible they are graded so as to be increasingly difficult, though this is not always a feasible or strictly necessary plan.

1.	Ex.	7,	p.	11,	or Ex.	12,	p.	17	31.	Ex.	6,	p.	9,	or Ex.	34,	p.	47
2.	,,	36,	,,	51,	,,	47,	,,	65	32.	,,	92,	,,	135,	,,	90,	,,	133
3.	,,	52,	,,	71,	,,	53,	,,	71	33.	,,	76,	,,	107,	,,	78,	,,	110
4.	,,	14,	,,	19,	,,	17,	,,	22	34.	,,	77,	,,	107,	,,	38,	,,	52
5.	,,	68,	,,	89,	,,	69,	,,	91	35.	,,	71,	,,	93,	,,	72,	,,	95
6.	,,	8,	,,	11,	,,	70,	,,	91	36.	,,	64,	,,	87,	,,	98,	,,	141
7.	,,	42,	,,	59,	,,	39,	,,	55	37.	,,	128,	,,	173,	,,	129,	,,	173
8.	,,	10,	,,	15,	,,	9,	,,	13	38.	,,	99,	,,	143,	,,	93,	,,	137
9.	,,	11,	,,	15,	,,	48,	,,	65	39.	,,	103,	,,	145,	,,	100,	,,	143
10.	,,	2,	,,	3,	,,	4,	,,	6	40.	,,	18,	,,	22,	,,	15,	,,	19
11.	,,	3,	,,	6,	,,	28,	,,	43	41.	,,	66,	,,	87,	,,	16,	,,	19
12.	,,	41,	,,	57,	,,	45,	,,	61	42.	,,	139,	,,	191,	,,	144,	,,	199
13.	,,	40,	,,	55,	,,	106,	,,	147	43.	,,	88,	,,	130,	,,	97,	,,	141
14.	,,	75,	,,	105,	,,	82,	,,	118	44.	,,	94,	,,	137,	,,	101,	,,	145
15.	,,	19,	,,	25,	,,	37,	,,	52	45.	,,	110,	,,	153,	,,	112,	,,	155
16.	,,	13,	,,	17,	,,	50,	,,	69	46.	,,	27,	,,	41,	,,	26,	,,	39
17.	,, 20 and 21, p. 32,				These examples				47.	,,	147,	,,	205,	,,	146,	,,	203
18.	,, 22 and 23, p. 35,				should be done for *any* course.				48.	,,	142,	,,	197,	,,	141,	,,	193
									49.	,,	108,	,,	151,	,,	43,	,,	59
19.	,,	89,	p.	133,	or Ex.	91,	p.	135	50.	,,	109,	,,	151,	,,	35,	,,	47
20.	,,	125,	,,	171,	,,	126,	,,	171	51.	,,	155,	,,	222,	,,	156,	,,	222
21.	,,	24,	,,	37,	,,	25,	,,	37	52.	,,	149,	,,	209,	,,	150,	,,	211
22.	,,	127a,	,,	171,	,,	127b,	,,	171	53.	,,	79,	,,	110,	,,	81,	,,	114
23.	,,	122,	,,	169,	,,	123,	,,	169	54.	,,	95,	,,	137,	,,	54,	,,	71
24.	,,	114,	,,	157,	,,	111,	,,	153	55.	,,	115,	,,	159,	,,	145,	,,	201
25.	,,	31,	,,	45,	,,	32,	,,	45	56.	,,	57,	,,	75,	,,	61,	,,	81
26.	,,	135,	,,	185,	,,	131,	,,	179	57.	,,	60,	,,	79,	,,	62,	,,	81
27.	,,	136,	,,	185,	,,	132,	,,	179	58.	,,	117,	,,	161,	,,	130,	,,	177
28.	,,	137,	,,	187,	,,	140,	,,	191	59.	,,	153,	,,	219,	,,	152,	,,	217
29.	,,	55,	,,	73,	,,	65,	,,	87	60.	,,	138,	,,	189,	,,	151,	,,	215
30.	,,	85,	,,	125,	,,	83,	,,	122									

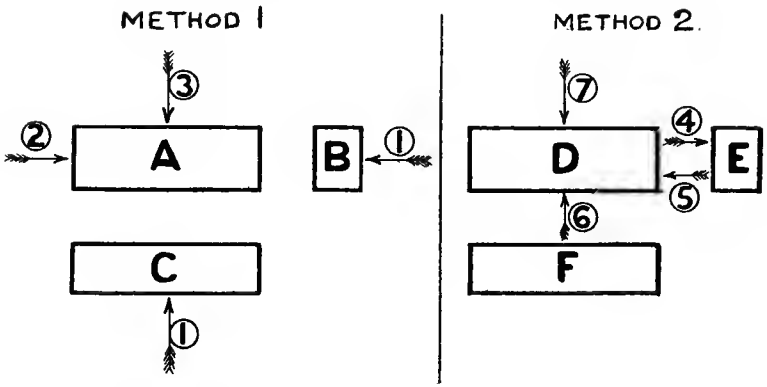
INTRODUCTION

WORKING Drawings.—The majority of the examples included in this book call for the making of *working drawings*, and Plates Nos. 1 and 2 show specimen working drawings as used by two up-to-date engineering firms.

To have *one* detail only on each shop print seems to be the modern conception of a working drawing. Though more work for the drawing office staff is entailed, the saving of time in the works when this system is adopted, more than compensates for the extra cost of the drawing office work.

Where half a dozen or more details of a machine are shown on one drawing, a practice still common with probably the majority of firms, much time is wasted and the progress of work in the shops considerably retarded by the fact that several workmen may be requiring the drawing at the same time. Since blue prints are so cheap and are so quickly made this difficulty is sometimes overcome by having several copies of a drawing issued to the works. This remedy is, however, not without its defects. However good the "drawing registration" in a works may be, "shop copies" will get mislaid, and if alterations to a drawing require to be made, there is always the chance that one or more of the shop copies will be missing at the time the alterations are made. The consequences are perhaps too obvious to need comment.

Arrangement of Views.—The Method of Projection used in making the illustrations in the following pages is the method most frequently used in this country. It is therefore suggested that the same method should be generally adhered to by the student. At the same time the student should indubitably be acquainted with the other method of projection which is used by many, but not by the majority of engineers. The difference between the two methods will be clearly understood by reference to the following sketches.



In Method No. 1 (the method adopted for the plates in this book) a view placed in position **A** is taken looking in the direction indicated by arrow (**1**). A view placed in position **B** is taken looking in the direction of arrow (**2**) and a view placed in position **C** is taken looking in the direction of arrow (**3**).

In Method No. 2, view **D** is taken looking in the direction of arrow (**4**), view **E** looking in direction of arrow (**5**), and view **F** in direction of arrow (**6**). This method is sometimes modified by making view **F** a view looking in direction of arrow (**7**).

It may be conceded in favour of the second method that it is much more convenient to use in "certain cases" than is the first method. As an example consider the case of the general arrangement drawing of a locomotive where, in addition to a longitudinal elevation, an end elevation looking on the smoke-box and an end elevation looking on the footplate end may be required. It is obviously easier to read the drawing if the views are arranged by Method No. 2 rather than by Method No. 1, and there are numerous similar examples of a like character which might be named. For the vast majority of cases, however, it may be assumed that Method No. 1 is the better one. In reading a drawing it is usually a simple matter to determine in which direction a view has been taken. Where this is not perfectly obvious a definite statement in writing should be made by the draughtsman on the drawing. This is particularly desirable in depicting articles which may be made right- or left-handed.

Number of Views Required.—Whatever differences of opinion there may be as to the Method of Projection, there can be only one opinion as to the *number* of views that are *essential*. The *complete shape* of the object depicted must be shown. It may require one, two, three, or even more views, but unless the com-

plete shape is clearly indicated the drawing is not a good *working drawing*. It sometimes happens that so many dimensions are required that it is advisable to add an extra view on which some of the dimensions may be placed in order to avoid unduly crowding the other views. This extra view, however, adds nothing to the information regarding shape.

Dimensioning.—Working drawings are usually fully dimensioned. In addition to depicting the complete shape, every size or dimension is given, so that the drawing forms a complete record of the object illustrated.

It is the practice with some engineering firms to provide for the machine shops special copies of the working drawings on which are given *only those dimensions relating to machining.* In some cases this refinement is carried still further and each section of the machine shop is provided with its own specially dimensioned print. For example, a casting which in turn requires drilling, turning, and milling operations would involve the use of three different blue prints. The print supplied to the driller contains only those dimensions relating to the size, number, and positions of the holes that have to be drilled. The print provided for the turner will show only those dimensions giving the diameters, lengths, and positions of the turned surfaces. The milling machine operator works to a print on which appear only the dimensions necessary to enable him to carry out the milling operation. In short every process has its own specially dimensioned print provided for it. Undoubtedly there is much to be said for both these ideas as the saving of time in the machine shops which results must be considerable. As a set off against this time saving in the works there has to be taken into account the extra drawing office work involved, the multiplicity of tracings and prints, and the extra filing, registration, etc.

Whatever type of print is deemed most suitable for the machine shops it is essential that the pattern-makers and smiths should be supplied with prints containing practically every dimension, and the engineering firms using this type of print as their standard shop copy are still in a large majority.

In dimensioning a drawing it is the practice in some offices to use inches and parts thereof. In others feet and inches are used, any dimension over 12″ being expressed in feet and inches. In other offices where feet and inches are used, feet are not introduced for any dimension under 24″. This is largely a matter of taste, influenced somewhat by the length of measuring staffs in use. There is no law controlling this matter. All that need be said concerning it is that if "feet"

are used there should be a distinct gap, with a horizontal line across it, between the figures representing feet and those representing inches, as thus 2′—2″, and not thus 2′ 2″. The student will probably have learned by this time that apart from decimal parts of inches the inch fractions used by engineers are halves, quarters, eighths, sixteenths, thirty-seconds and sixty-fourths, and occasionally $\frac{1}{128}$″. The use of any other fraction is not permissible.

Indication of Machined Surfaces.—Probably in the majority of cases nowadays the surfaces that require to be machined are indicated in some way on the working drawing. In some offices it is the practice to do this on the blue print only, the custom most in vogue being to line the surfaces with red, a colour brush being used for the purpose. This is admittedly an effective method of calling the workman's attention to the surfaces requiring machining. The principal objection to it, in the writer's opinion, is that the information relating to machining is not recorded permanently on the tracing, and that each time a new blue print is required the red lining of the print has also to be done. This difficulty is sometimes overcome by red lining the tracing which gives a faint white blurred line on the print, a result not altogether satisfactory so far as the print is concerned. Unfortunately there is no standard method of indicating machined surfaces, though the one illustrated in the specimen drawing on Plate No. 2 is probably the one most frequently used. In this case a small letter *f* is printed *across* the line representing the surface that requires machining. In the specimen drawing shown by Plate No. 1 a large letter *F* printed *close to* the line answers the same purpose. Both these methods may be described as good, a description which the writer would hesitate to apply to some other methods which are in vogue. It is suggested therefore that one of these two methods be adopted by students and applied in every case where a working drawing is made.

The plates in this collection are so generally crowded with reference letters and numbers that it was not considered advisable to further complicate the illustrations by indicating the machined surfaces. Students will, however, profit considerably by an endeavour to determine for themselves which surfaces require machining.

Sizes of Drawings, etc.—There are no universal standards governing the sizes of the sheets or the arrangement of marginal columns or the information contained therein. Every drawing office is a law unto itself and has its own standard sizes and arrangement of sheets, usually dictated by the class of work

being dealt with and sometimes controlled by the available filing accommodation for office or shop copies of the drawings. The originals of the specimen drawings shown on Plates Nos. 1 and 2 are from different firms, equally eminent in the engineering world, and dealing with precisely the same class of work. As will be seen by comparison, the arrangement of the marginal columns and the information contained therein are entirely different in the two cases. The size of the two originals is also different, whilst the difference in the method of indicating the machined surfaces has already been noted.

In some offices a double elephant sheet (40″ × 27″) is the standard, whilst in others "Imperial" (30″ × 22″) is found to be more convenient. In either case, when small separate detail working drawings such as the two illustrated on Plates Nos. 1 and 2 are required, the standard office sheet is divided into the required number of spaces which may be four, six, or eight, according to convenience. Suppose a double elephant sheet contains say six detail drawings. The sheet may be blue printed as a whole and the print cut up into six small sheets. Each of these sheets may then be mounted on a piece of cardboard for use as the "shop copy" in the works. This is the practice most commonly followed. It may be noted that the sheets of tracing linen may be procured with the marginal columns and various headings ready printed to requirements. This effects a great saving of drawing office time, the extra cost of the tracing linen, due to the printing, being almost negligible by comparison with the time saved. Working drawings being produced in so many varieties of form, some being specially applicable to some particular class of work or to suit some special system of organisation, it is suggested that for ordinary class work the student should not follow the system of any particular engineering firm. He should work on lines which, broadly interpreted, are applicable to most first class systems and the following regulations covering the making of working drawings are offered as a guide.

(1) The drawing should show the complete *shape* of the object depicted.

(2) Every size or dimension should be given.

(3) All machined surfaces should be indicated.

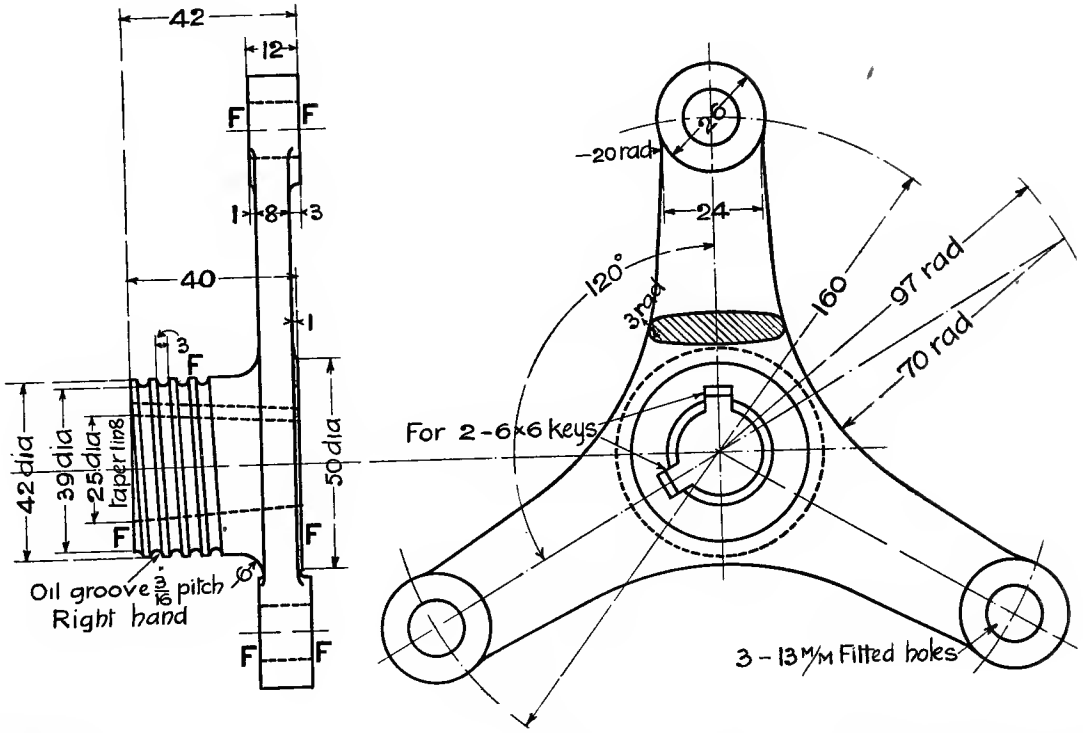
(4) The name of the part, the material of which it is made, and the number required should be stated.

(5) The title and scale should be neatly printed.

(6) Where more than one detail is shown on a drawing a "description list" similar to those accompanying the majority of the plates in this book will be found to be the

most convenient way of giving the particulars required by regulation (4).

Before proceeding with any of the examples students are recommended to read carefully through the description list and text accompanying each plate. Indeed the description list is a part of the drawing and the plate cannot be interpreted without its aid. In numerous cases dimensions, which it was found to be inconvenient or inexpedient to place on the drawing, are given in some form in the description list. In some cases where it has been impossible to give dimensions either on the drawing, owing to exigencies of space, or in the list, the dimensions may be scaled.



DRAWN BY	RC	5-1-18
TRACED BY	H.L	5-1-18
CHECKED BY	HME	9-1-18

UNIVERSAL JOINT STAR (FRONT)

1 OFF	M.S	D.F	352.C

SPECIMEN WORKING DRAWING

A specimen working drawing is illustrated on this plate, the original from which the drawing for the block was copied being supplied by a well-known firm of motor manufacturers. The size of the original print is $13\frac{1}{2}'' \times 10''$, suggesting that in this case a "double elephant" sheet ($40'' \times 27''$) is divided into eight spaces, each one of which will contain a separate detail working drawing.

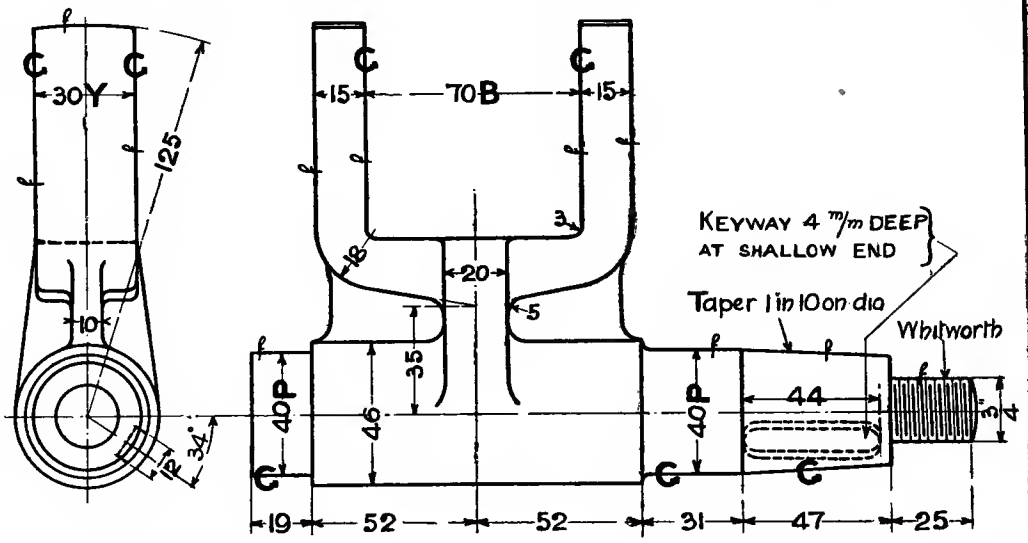
In this instance the marginal information is confined to a statement of the name of the part, the number required, the material (M.S., denoting Mild Steel), the method of production (D.F., indicating Drop Forging), and the drawing number. Provision is also made for the initials of the draughtsman, tracer, and checker, and for dates.

It is quite a common custom where the system of "one drawing, one article" is adopted, to use the "drawing" number as the "part" number also, and to stamp the number on the part. The student's attention is directed to the method of dimensioning adopted. In the longitudinal elevation (on the left) it will be noticed that every dimension is given **to or from** a machined surface. In the end elevation all the dimensions are to or about centre lines. These methods should **always** be adopted, as only by so doing can strict accuracy be guaranteed. It should also be noted that no dimensions are repeated, and that none are given which are superfluous.

Where three or more views of an object are given it frequently happens that there is a repetition of the same dimension on different views, and sometimes this is a convenience to anyone using the drawing. As a general rule, however, it is best to avoid this repetition of dimensions, as, in case of alterations being made, there is always the liability of a dimension being altered in one view and not in another. In this example the dimensions are in millimetres. The machined surfaces are indicated by the letter (F), which is printed close to the lines representing the surfaces which require machining.

PLATE No. 2

X.Y.Z. & Co. LONDON.



ALTERATIONS

TOOLS & JIGS

STEERING FORK

DRAWN BY	P.R.
CHECKED BY	H.W.S.
PASSED BY	F.A.V.
DATE	7.5.19

⊖ MACHINED ALL OVER
f MACHINED
C GROUND
R ROUGH MACHINED

ALL "NEWALL" STANDARD LIMITS.

P PUSH FIT — X RUNNING FIT
D DRIVING FIT — Y " "
F FORCE FIT — Z " "
B FOR HOLES

MATERIAL	Steel No 2
MADE FROM	Stamping
WEIGHT ROUGH	WEIGHT FINISHED

TYPE No OFF

PART NO
B 245

SPECIMEN WORKING DRAWIN G

A specimen working drawing as used by a firm which has adopted the Newall System of Gauges is shown on the accompanying Plate No. 2. The first column of reference is easy of interpretation, the symbols used being similar whether or not a limit gauge is involved. Thus, in the illustration, all the surfaces marked with the letter ("*f*") have to be machined, those marked (G) being also "ground" after machining. To enable the student to appreciate the meaning of all the references in the second column (headed, "All Newall Standard Limits") the Newall Engineering Co. have been kind enough to allow the inclusion here of the following notes from their book on "Gauges".

Tolerances for standard holes are in two grades, Classes A and B, the selection of which is for the user's decision, and is dependent on the quality of the work required.

Allowances for shafts are as follows:—

FORCE FITS: CLASS F.—The shafts made to this table require hydraulic pressure to force them into the holes. The allowances made are also suited for cases where one piece is shrunk on to another by heating and expanding the hole in one piece and allowing it to cool and contract in position on the other piece.

DRIVING FITS: CLASS D will produce shafts that need to be **driven** into the holes.

PUSH FITS: CLASS P.—Shafts made to these limits can be pushed into the holes, but will not be sufficiently free to rotate without seizing.

RUNNING FITS are divided into three grades. Class X for engine and other work where **easy** fits are wanted.

CLASS Y for high speeds and good average machine work.

CLASS Z for fine tool work.

The following extract from the "Gauge List" will now render possible a correct interpretation of the drawing:—

TOLERANCES IN STANDARD HOLES: CLASS B.		PUSH FITS: CLASS P.		RUNNING FITS: CLASS Y.	
Nominal Diameters	51 to 75 mm.	Nominal Diameters	26 to 50 mm.	Nominal Diameters	26 to 50 mm.
High Limit	+ ·032 ,,	High Limit	− ·006 ,,	High Limit	− ·032 ,,
Low ,,	− ·019 ,,	Low ,,	− ·019 ,,	Low ,,	− ·064 ,,
Tolerance	·051 ,,	Tolerance	·013 ,,	Tolerance	·032 ,,

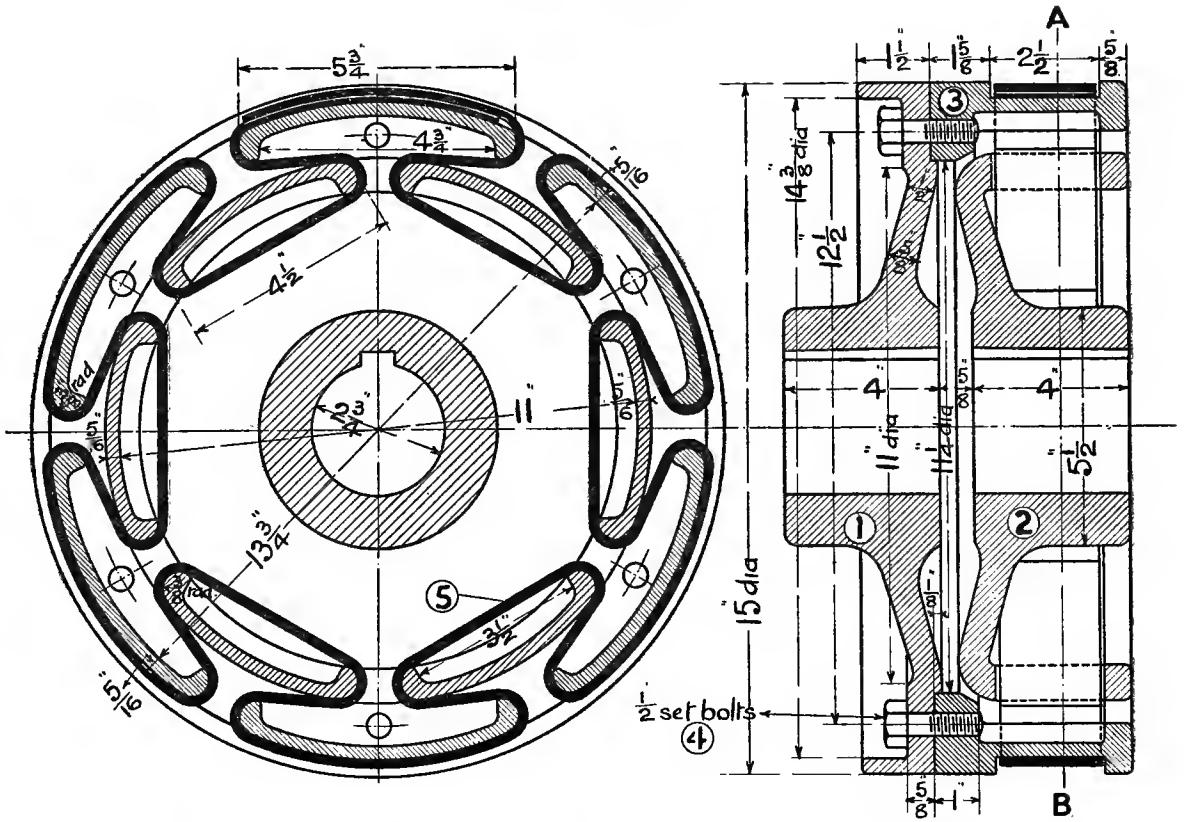
Referring to the drawing, the distance between the arms of the fork is given as 70 B. This means that this dimension may be 70 + ·032 mm. as a maximum or 70 – ·019 as a minimum, **any** size **between** these limits being acceptable, and the gauges are so made that sizes **between** these limits **only** will pass them. The two portions of the fork spindle dimensioned 40 P must not be greater than 40 – ·006 mm. nor less than 40 – ·019 mm. in diameter to pass the gauges. Similarly, the width of the forks, dimensioned 30 Y, must not be greater than 30 – ·032 nor less than 30 – ·064 mm.

It may be noted that the terms "tolerance" and "allowance" represent quite distinct quantities. Tolerance is the margin provided for reasonable error in workmanship. Allowance is the **necessary** difference in the size of two pieces that have to go together to obtain the kind of fit required.

SECTION I

GENERAL ENGINEERING

PLATE No. 3


A
B
5 3/4"
4 3/4"
4 1/2"
11"
2 3/4"
13 3/4"
3 1/2"
5/16"
15" dia
14 3/8" dia
12 1/2"
11" dia
11 1/2" dia
5 1/2"
2 1/2"
1 1/2"
1 5/8"
5/8"
1"
4"
1/2" set bolts
(1)
(2)
(3)
(4)
(5)

FLEXIBLE COUPLING FOR SHAFTS

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Half-Coupling (Large) . .	Cast Iron	1	251
2	,, ,, (Small) . .	,,	1	252
3	Outer Ring	,,	1	253
4	Hex. Hd. Set Bolts . .	Mild Steel	6	$\frac{1}{2}''$ × $1\frac{5}{8}''$
5	Belt	Leather	1	$2\frac{1}{4}''$ × $\frac{3}{8}''$ section
6	Rivets	Copper	—	——

An "Empire" Flexible Coupling, as made by Messrs. Crofts, Ltd., is shown on the accompanying plate No. 3.

The coupling consists of two discs (1) and (2), which are keyed to the shafts in the usual manner. The keyways provided are to suit British standard keys. The smaller of these discs has a rim in which there are six rectangular openings cored at equal intervals round the periphery. Fastened to the larger disc is a separate rim (3) having the same number of similar openings. The belt, which forms the flexible element of the coupling, is interlaced through the openings of the two rims in the manner indicated in the end view, the two ends of the belt being finally riveted together.

The coupling illustrated will transmit about 40 h.p. at 500 r.p.m., or 80 h.p. at 1000 r.p.m. under very favourable conditions, i.e. steady load without sudden fluctuations. These couplings are specially adapted for use with electric motors and dynamos, as in addition to the flexibility provided, the belt forms an efficient insulator. The end elevation is a section on line (AB).

Example 1.—Make separate detail working drawings of items **1, 2,** and **3.**

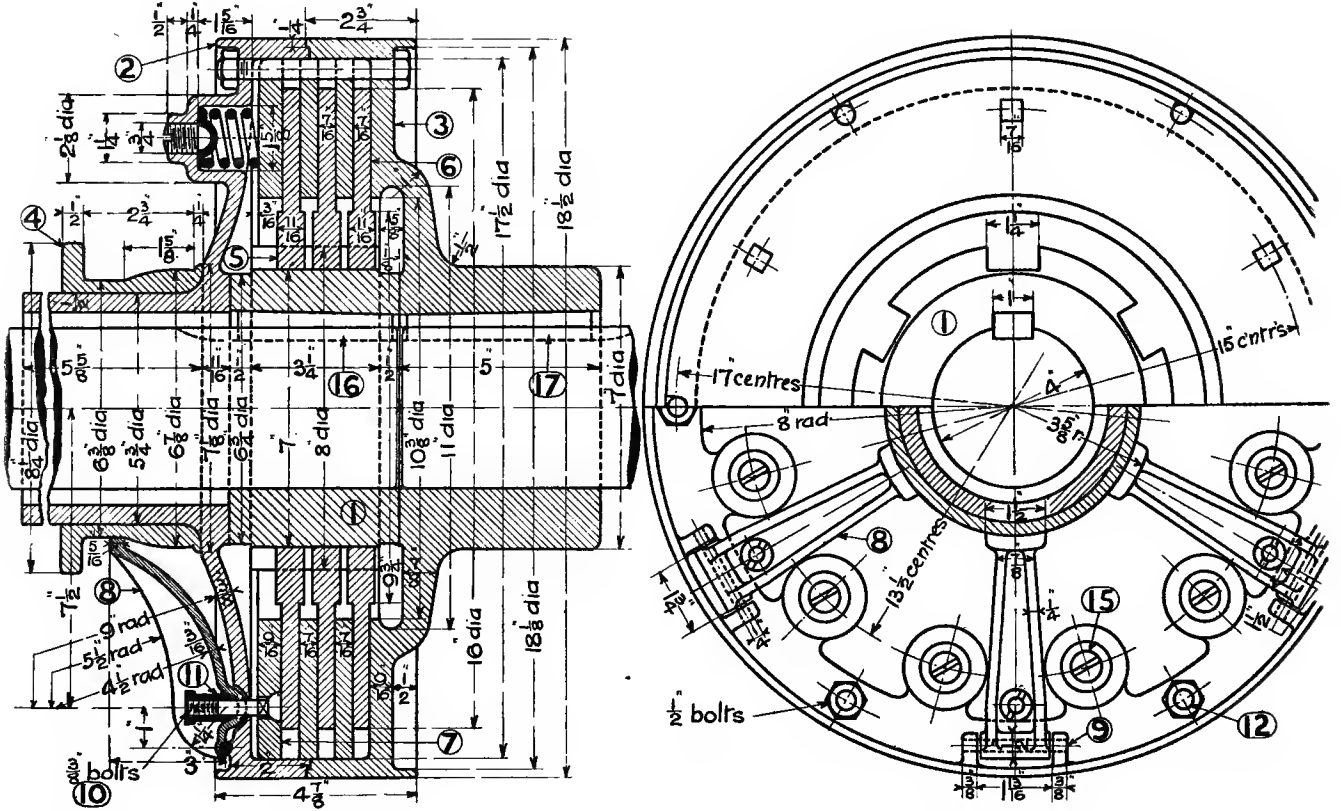
Example 2.—Make a complete drawing of a similar coupling suitable for shafts, $3\frac{1}{2}''$ diameter, working as closely as possible to the following dimensions:—

Diameter of each hub, $7''$. Length through each hub, $4\frac{5}{8}''$. Distance between hubs, $\frac{3}{4}''$. Outside diameter of coupling, $20''$.

Outside diameter of rim on small disc, $14''$.

Section of belt, $3'' \times \frac{3}{16}''$. Loose rim fixed to large disc by eight $\frac{5}{8}''$ set bolts, equally spaced on a circle about $17\frac{1}{2}''$ diameter. Eight openings in each rim for belt. Note! This coupling will transmit roughly twice the power of the one illustrated.

PLATE No. 4


2¾
2⅜ dia
2¾
18½ dia
17½ dia
17 dia
8¼ dia
6⅜ dia
5¼ dia
6⅞ dia
7⅛ dia
6¼ dia
7 dia
8 dia
10⅜ dia
11 dia
16 dia
18⅜ dia
9 rad
5½ rad
4½ rad
4⅛
bolts
17 centres
15 cntrs
8 rad
13½ centres
bolts
1
2
3
4
5
6
7
8
9
10
11
12
15
16
17

BENN PATENT FRICTION CLUTCH

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Driving Boss . . .	Cast Iron	1	314
2	Front Cover	,,	1	315
3	Back Cover	,,	1	316
4	Muff	,,	1	317
5	Driving Plates . . .	,,	3	318
6	Friction Plates . . .	,,	2	319
7	End Friction Plate . .	,,	1	320
8	Lever	Malleable Cast Iron	6	321
9	Fulcrum Pins . . .	Mild Steel	6	$\frac{1}{4}$″ dia. $2\frac{5}{8}$″ long
10	Spherical Headed Bolts .	Mild Steel	6	$\frac{3}{8}$″ dia. $2\frac{3}{8}$″ long
11	,, Seated Nuts . .	,,	6	$\frac{3}{8}$″ dia. $1\frac{1}{4}$″ long
12	Hex. Hd. Bolts with Hex. Nuts	,,	6	$\frac{1}{2}$″ dia. $4\frac{1}{2}$″ long
13	Helical Springs . . .	Spring Steel	6	wire $\frac{1}{4}$″ dia. coil $1\frac{1}{4}$ dia. centres
14	Pressure Plates for Springs .	Mild Steel	6	—
15	Adjusting Screws . .	,,	6	$\frac{3}{4}$″ × 1″
16	Key for Driving Boss . .	Key Steel	1	1″ × $\frac{11}{16}$″ × $3\frac{7}{8}$″
17	,, Back Cover . .	,,	1	1″ × $\frac{11}{16}$″ × $4\frac{5}{8}$″

A general arrangement of the Benn Patent Friction Clutch is given on the accompanying plate No. 4.

The clutch, as shown, is suitable for connecting two 4″ diameter shafts together. The power that may be transmitted depends largely on the nature of the work being done. If the drive is a steady one and the starting load light the clutch shown in the illustration is capable of transmitting about 75 h.p. at 200 r.p.m. If, however, a large starting torque is required and the load subject to violent fluctuations the clutch is only suitable for about half the power named.

The action of the clutch will be fairly obvious on inspection of the illustration. The clutch is shown in the closed or driving position. To disengage it the muff (4) is forced along the extended boss of the front plate by means of a lever not shown. This causes the levers (8) to be forced outwards, giving sufficient movement to plate (7) through the spherical bolts to overcome the pressure of the springs.

The driving plates (5) are threaded on to the driving boss (1), the latter being keyed to one of the shafts by a standard section key (16). The friction plates (6) and (7) are threaded on to the bolts (12), which also pass through the back plate (3), the back plate being keyed to the shaft to which the drive is being transmitted.

The friction surfaces are pressed together by adjustable helical springs which automatically take up the wear of the plates and ensure shockless engagement. The ends of the two shafts are $\frac{1}{16}$″ apart. The upper half of the

BENN PATENT FRICTION CLUTCH (*continued*)

end elevation is a view with the front cover (2), the levers (8), and the muff (4) removed, so as to show how the driving plates are attached to the driving boss, tongues on the plates fitting slots in the boss. The connection of the friction plates to the back plate through the medium of the bolts (12) is also clearly shown. This clutch requires no lubrication.

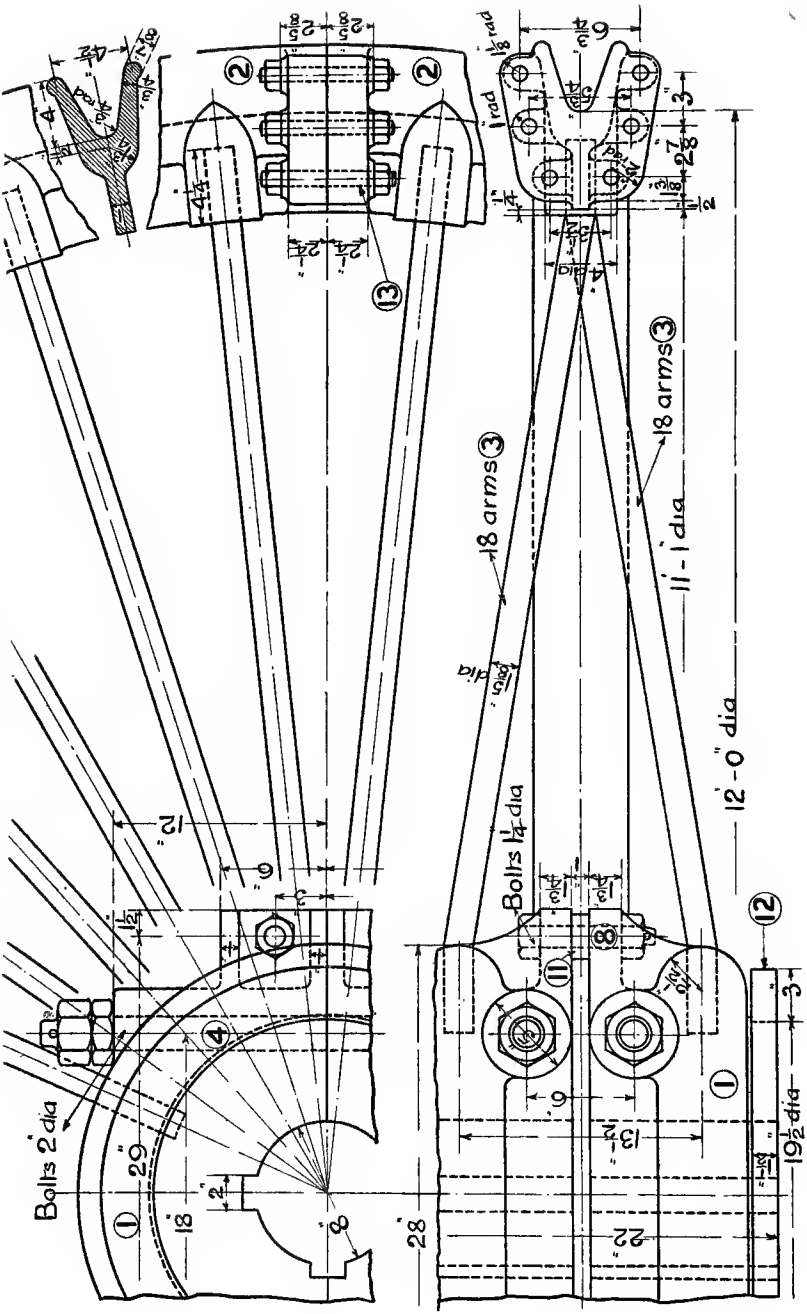
The fulcrum pins (9) are cast in position in the front plate (2).

EXAMPLE 3.—Make separate detail working drawings of each item.

EXAMPLE 4.—Design a similar clutch for shafts $2\frac{1}{2}''$ diameter, working as closely as possible to the following dimensions: Greatest diameter, $12\frac{1}{2}''$; length through hub of back plate, $3\frac{1}{4}''$; length through driving boss, $2''$; greatest over-all length, $9\frac{1}{2}''$. Use two driving plates and two friction plates.

EXAMPLE 5.—Trace the drawing made to Example 4.

PLATE No. 5


Bolts 2" dia
Bolts 1¼" dia
18 arms ③
18 arms ③
11'-1" dia
12'-0" dia
19½" dia
28"
22"
13½"
29"
18"
12"
6"
8"
① ② ③ ④ ⑧ ⑪ ⑫ ⑬

HEAD GEAR PULLEY FOR COLLIERY SHAFT

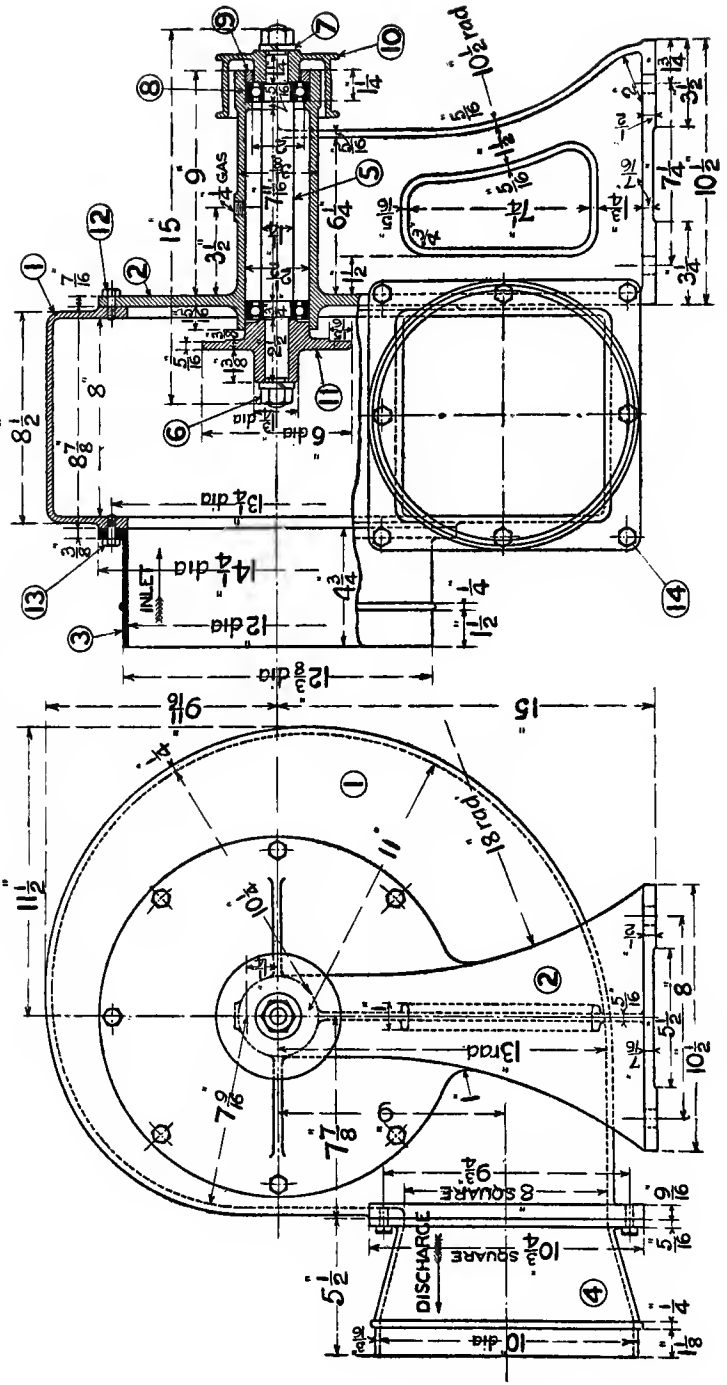
Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Hub (in four parts) . .	Cast Iron	1	1851
2	Rim (in halves) . . .	,,	1	1852
3	Arms	Mild Steel	36	$1\frac{5}{8}$″ dia. × 31″
4	Hex. Hd. Bolts . . .	,,	4	2″ × $28\frac{1}{4}$″
5	,, Nuts for Bolts .	,,	4	2″ standard
6	,, Lock Nuts for Bolts .	,,	4	2″ standard
7	Split Pins for Bolts . .	,,	4	$\frac{3}{8}$″ × $3\frac{1}{2}$″
8	Hex. Hd. Bolts . . .	,,	4	$1\frac{1}{4}$″ × $6\frac{1}{4}$″
9	,, Nuts for Bolts . .	,,	4	$1\frac{1}{4}$″ standard
10	Split Pins for Bolts . .	,,	4	$\frac{1}{4}$″ × $2\frac{1}{2}$″
11	Packing Rings ($1\frac{3}{8}$″ dia. hole)	,,	4	1″ thick $2\frac{1}{2}$″ dia.
12	Hoops $25\frac{1}{2}$″ outs. dia., $19\frac{1}{2}$″ ins. dia.	Wrought Iron	2	$1\frac{1}{2}$″ thick
13	Double-nutted Bolts . .	Mild Steel	12	$\frac{7}{8}$″ × $7\frac{1}{4}$″
14	Hex. Nuts for Bolts .	,,	24	$\frac{7}{8}$″ standard

A part general arrangement of a Head Gear Pulley is shown on this plate. The rim is made in halves, the halves being bolted together by means of twelve bolts in the manner indicated, headless bolts being used because bolts with heads could not be placed into position.

The hub of the pulley is made in four pieces, the way in which these are fixed being clearly shown in the illustration. The hub is bored with a very thin packing strip between the two halves, so that when the pulley is placed in position on the shaft, and the nuts of the 2″ diameter bolts are tightened up, the hub will nip the shaft. The wrought-iron hoops (item **12**) are shrunk on after the pulley is placed on the shaft. The spokes are cast in both the hub and the rim. The keyways in the hub are to suit British standard keys.

Example 6.—Make a complete working drawing showing the whole pulley.

PLATE No. 6


INLET
DISCHARGE
6 dia
8 SQUARE
10 SQUARE
10 dia
12 dia
13 rad.
18 rad.
15"

HOUSING FOR SIROCCO FAN

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Casing	Cast Iron	1	1056
2	Pedestal and Bearing Housing	,,	1	1057
3	Suction Eye	,,	1	1058
4	Discharge Mouthpiece	,,	1	1059
5	Shaft	Mild Steel	1	$1\frac{1}{4}$" dia. 15" long
6	Hex. Nuts for Shaft	,,	2	
7	Grover Spring Washers	Spring Steel	2	$\frac{5}{8}$"
8	Radial Ball-bearings	Hardened Steel	2	—
9	Locking Ring for Bearing	Mild Steel	1	$2\frac{1}{2}$" dia. $\frac{1}{2}$" thick
10	Pulley	Cast Iron	1	1060
11	Hub for Fan	Cast Iron	1	1061
12	Hex. Hd. Set Bolts (Casing to Pedestal)	Mild Steel	7	$\frac{1}{4}$" × $\frac{7}{8}$"
13	Hex. Hd. Set Bolts (Suction Eye to Casing)	,,	8	$\frac{1}{4}$" × $\frac{7}{8}$"
14	Hex. Hd. Set Bolts (Discharge to Casing)	,,	8	$\frac{1}{4}$" × $\frac{7}{8}$"
15	Lubricator (Stauffer)	Brass	1	No. 4
16	Grub Screws for Pulley and Fan Hub	Mild Steel	4	$\frac{5}{16}$" dia. $\frac{1}{2}$" long
17	Cup Hd. Screws for Locking Ring	,,	2	$\frac{3}{16}$" × $\frac{3}{8}$"

Complete details of the casing, pedestal, bearings, etc., for a belt-driven 10" Sirocco Fan are given in the illustration on the opposite page, the detail of the fan itself being omitted.

The fan shaft (**5**) runs on ball bearings, the inner race of the fan end bearing being held between a shoulder on the shaft and the fan hub. The inner race of the other bearing is similarly held, the outer race being locked by means of the ring (**9**), which itself is fixed to the housing by means of the screws (**17**), which are screwed half in the ring and half in the housing.

The diameter of the shaft in the bearings is 1", and in the fan hub, and pulley $\frac{7}{8}$". The boss for the $\frac{1}{4}$" Gas Stauffer Lubricator is 1" diameter × $\frac{1}{8}$" thick. The pulley (**10**) is $4\frac{1}{4}$" diameter and $2\frac{1}{8}$" wide between the flanges, the inside diameter of the rim being $3\frac{7}{8}$".

The flanges are $\frac{3}{16}$" thick and 5" diameter. The pulley hub is $1\frac{3}{4}$" diameter and $1\frac{1}{4}$" long through the bore.

The pulley (**10**) and the fan hub (**11**) are each fixed to the shaft by means of two grub screws (**16**), arranged at right angles to each other.

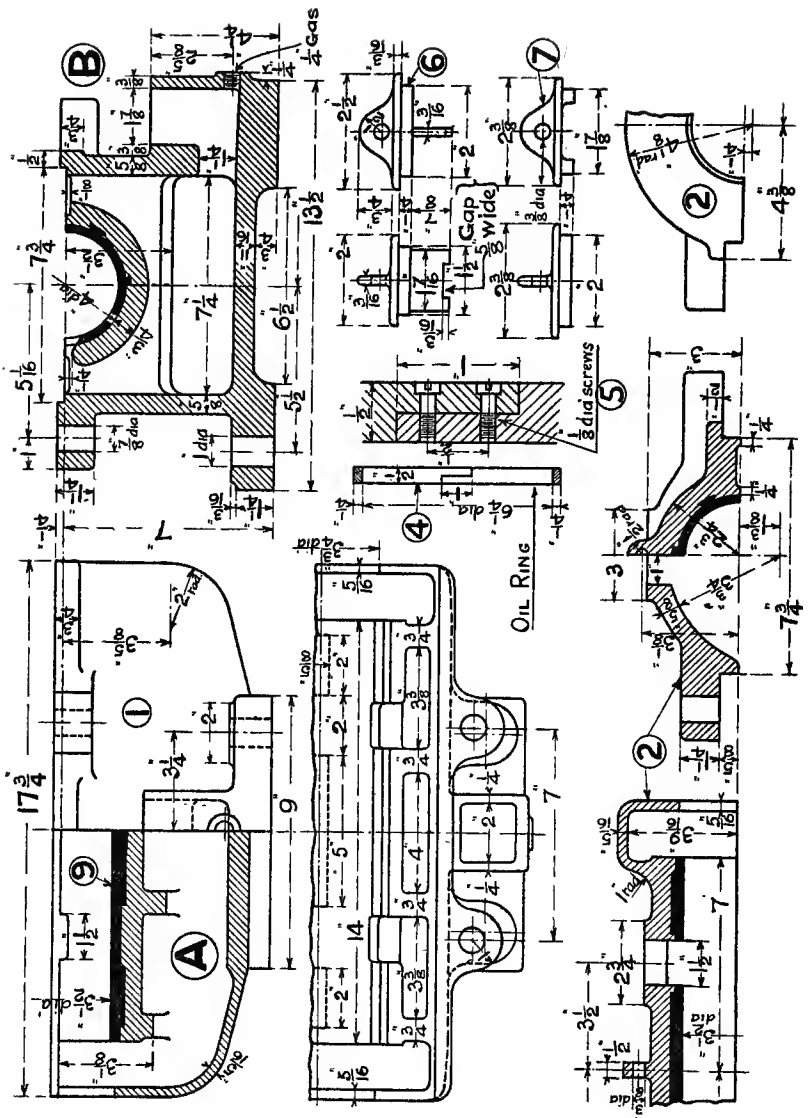
Example 7.—Separate detail working drawings are to be made of each of the following items: **1, 2, 3, 4, 5,** and **10.**

Items **1, 2, 3,** and **4** to be drawn half-size.

Items **5** and **10** to be drawn full size.

Example 8.—Make a tracing of items **1, 2,** and **4.**

PLATE No. 7



SHAFT-BEARING FOR MINE VENTILATING FAN

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Bearing Lower Half . .	Cast Iron	1	174
2	,, Upper Half . .	,,	1	175
3	Hex. Hd. Bolts with Hex. Nuts	Mild Steel	4	$\frac{3}{4}''$ × $3\frac{3}{4}''$
4	Oil Rings (in halves) . .	Gun Metal	2	176
5	Cheese Hd. Screws for Rings .	Mild Steel	4	$\frac{1}{8}''$ × $\frac{3}{8}''$
6	Inspection Covers . . .	Brass	2	177
7	Oil-box Cover . . .	,,	1	178
8	Chains for Covers . . .	,,	3	—
9	—	White Metal	—	—

Incomplete views of a Special Shaft-bearing are shown on this plate.

The bearing surface is white-metalled throughout, and the lubrication is of the ring type. The rings are two in number, and for convenience of insertion are made in halves, the method of fastening the two halves together being clearly indicated in the enlarged view.

The inspection and oil-box covers (6) and (7) are attached to the body of the bearing by short lengths of chain to prevent the covers being mislaid.

Example 9.—Make a drawing showing all the parts assembled together in their working positions, giving the following views:—

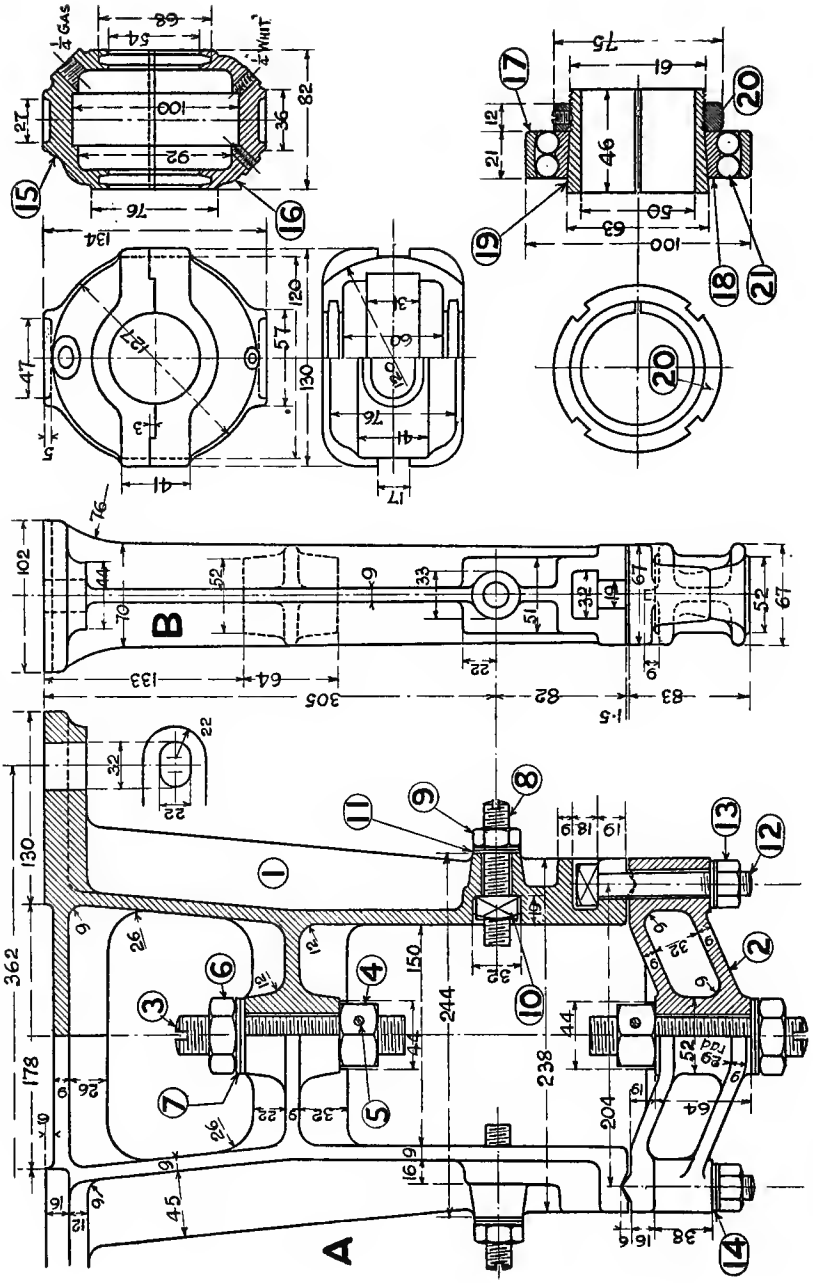
(1) A side elevation corresponding to view (A), the left-hand half in section, the right-hand half "outside view".

(2) An end elevation corresponding to view (B), the left-hand half being a section on the centre line of one of the oil rings, and the right-hand half a section on the centre line of the bearing.

(3) An "outside view" end elevation.

(4) A plan, the left-hand half being an outside view, and the right-hand half showing the bearing with the upper half (2) removed.

PLATE No. 8


A
B
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
362
130
178
244
238
204
150
305
133
64
82
83
102
76
68
54
100
92
36
82
27
124
127
120
57
47
130
41
76
17
75
61
46
63
50
100
12
21
GAS
WHIT

HANGER BRACKET WITH BALL-BEARING

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Hanger Frame . . .	Cast Iron	1	874
2	Bridge Piece . . .	,,	1	875
3	Vertical Adjusting Screws .	Mild Steel	2	1″ dia. × 6″
4	Hex. Nuts for Screws . .	,,	2	1″
5	Grub Screws . . .	,,	2	$\frac{5}{16}$″
6	Hex. Lock Nuts . . .	,,	2	1″
7	Thackray Spring Washers .	Steel	2	1″
8	Side Adjusting Screws . .	Mild Steel	2	$\frac{5}{8}$″ × 3$\frac{3}{4}$″
9	Hex. Lock Nuts . . .	,,	2	$\frac{5}{8}$″
10	Square Nuts . . .	,,	2	$\frac{5}{8}$″
11	Thackray Spring Washers .	Steel	2	$\frac{5}{8}$″

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
12	Square Head Bolts (black) .	Wro't Iron	2	$\frac{5}{8}$″ × 4″
13	Hex. Nuts (bright) . .	Mild Steel	2	$\frac{5}{8}$″
14	Thackray Spring Washers .	Steel	2	$\frac{5}{8}$″
15	Bearing Housing, Upper Half	Cast Iron	1	876
16	,, Lower Half	,,	1	877
17	Outer Ball Race . . .	Hardened Steel	1	—
18	Inner Ball Race . . .	,,	1	—
19	Split Bush	Mild Steel	1	—
20	Locking Nut	,,	1	—
21	Balls	Hardened Steel	38	$\frac{13}{32}$″ dia.

Details of a Hanger Bracket with Ball-bearing suitable for a line shaft are shown on the plate facing this page.

This bearing is designed to meet cases where it is impossible to provide means for locking the inner race by a taper seat or by a shoulder nut on the shaft itself, these methods being manifestly out of the question with a line shaft.

The inner race is bored slightly taper and is fitted with a split bush. The bush is provided with a screwed parallel extension fitted with a lock nut, and is made an easy sliding fit on the shaft.

When the nut is tightened up the race is locked to the tapered portion of the bush and the bush grips the shaft. The nut itself is locked by a grub screw.

Example 10.—Make a drawing showing all the parts assembled together in their working positions. Give the following views:—

(*a*) An end elevation, half sectional, half outside view, corresponding to view A.

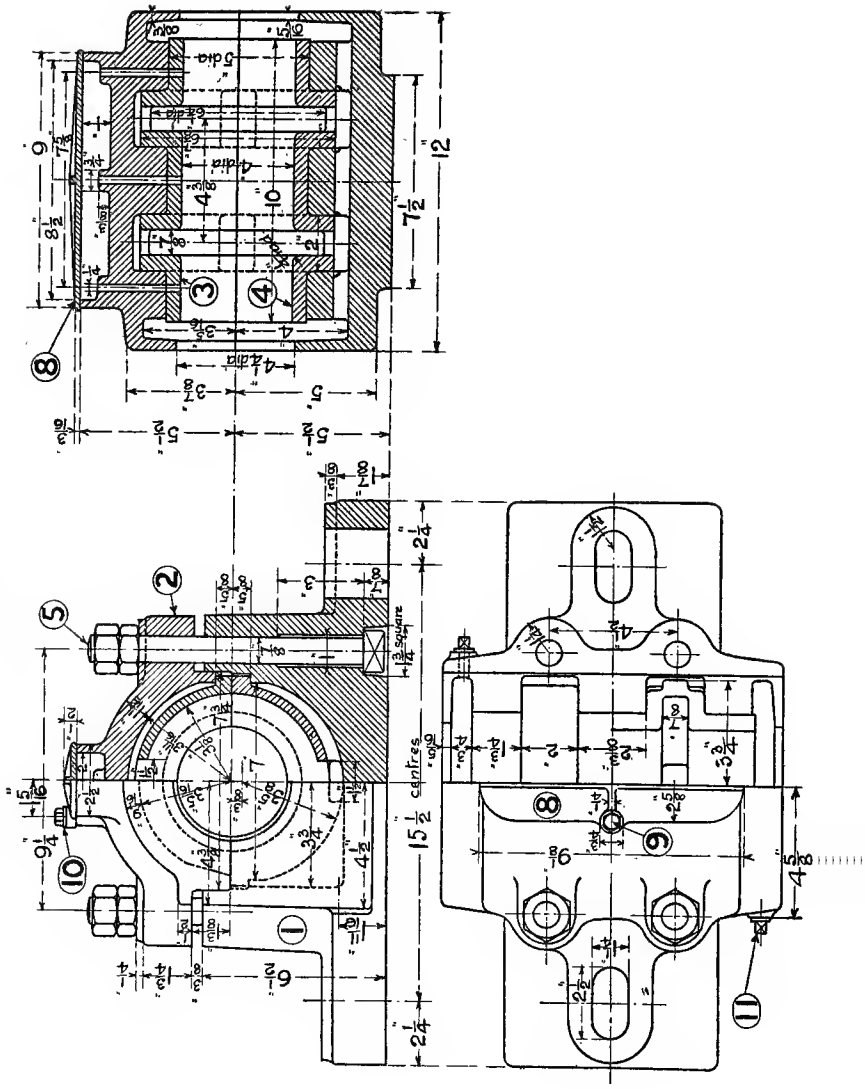
(*b*) A side elevation, outside view, corresponding to view B.

(*c*) A side elevation showing a section through the centre of the bearing.

(*d*) A plan, the left half being an outside view, the right half to show a section on the centre line of the bearing.

Example 11.—Trace the drawing made to Example 10.

PLATE No. 9



PEDESTAL THRUST-BEARING

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Pedestal Base . . .	Cast Iron	1	417
2	,, Cap	,,	1	418
3	Bearing Bush, Upper Half .	Gun Metal	1	419
4	,, Lower Half .	,,	1	419
5	Square Head Bolts for Cap .	Wrought Iron	4	$\frac{7}{8}'' \times 9\frac{3}{4}''$
6	Hex. Nuts for Bolts . .	Mild Steel	4	$\frac{7}{8}''$
7	,, Lock Nuts . .	,,	4	$\frac{7}{8}''$
8	Oil-box Lid	Cast Iron	1	420
9	Hex. Hd. Set Bolt . . .	Mild Steel	1	$\frac{5}{16}'' \times 1''$
10	Tbackray Spring Washer .	Steel	1	$\frac{5}{16}''$
11	Gas Plug for Drain Hole .	Mild Steel	2	$\frac{1}{8}''$ gas

A 4″ × 10″ Thrust-bearing is shown on this plate. The left-hand half of the front elevation is an outside view, the right-hand half being a conventional sectional elevation, the section being taken so as to pass through the centre of the base plate and also through the centre of one of the cap bolts. The other elevation is a longitudinal section on the centre line of the bearing.

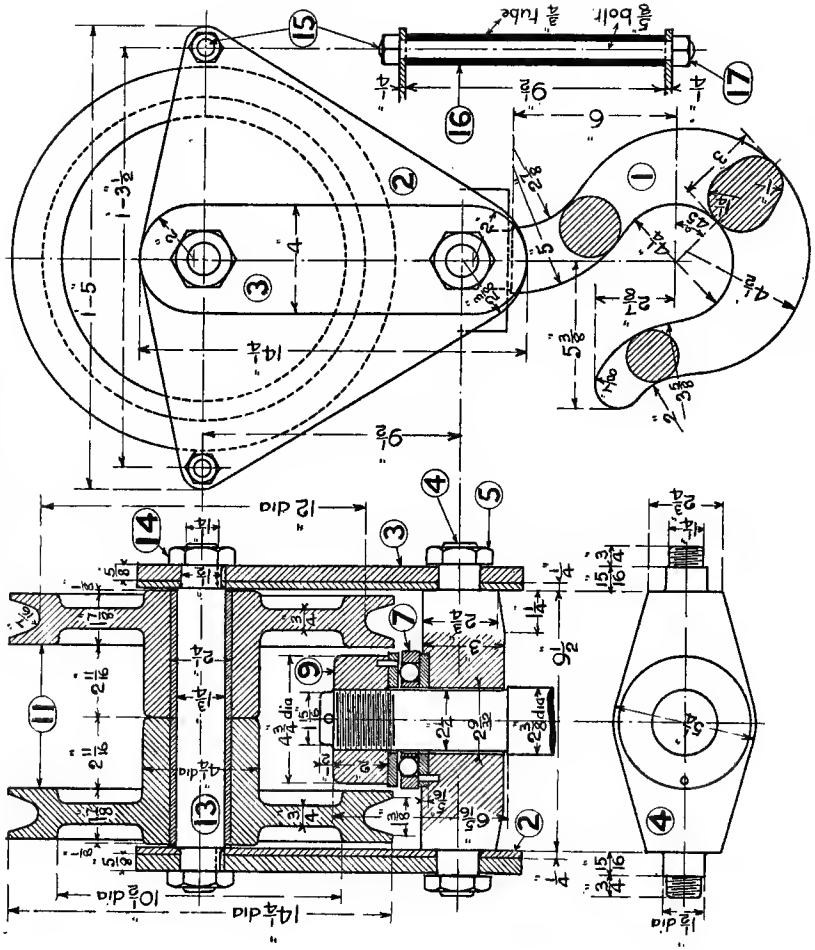
The left-hand half of the plan is an outside view. The upper portion of the right-hand half is a part plan of the pedestal base with the cap and bushes removed, the lower portion being a similar view, but with the lower half bush in position.

The "thrust" is taken by the collars on the brasses, there being two such collars in this particular size of bearing. Lubrication is by syphon from the oil-box formed in the cap, three oil holes being provided.

Example 12.—Make a separate detail working drawing of each of the following items: **1**, **2**, **3**, **4**, and **8**.

Example 13.—Design a similar bearing for a shaft 3″ diameter, working as closely as possible to the following dimensions: Nett bearing surface length, 6″; over-all length of bush, $7\frac{1}{2}''$; over-all length of casting, 9″; length of base, $14\frac{1}{2}''$; width of base, 6″; rise of bearing, $4\frac{1}{4}''$. Use four $\frac{3}{4}''$ bolts for fixing cap to base.

PLATE No. 10


5/8 Bolt
1/4 Tube
1/4
9 1/2
6
1/4
17
16
15
2
1
1-3 1/2
1-5
4
3
14 1/4
9 1/2
5 3/8
2 3/8
4 1/2
2 1/2
12 dia
14
5
4
7
2 1/4 dia
2 3/4
1 1/4
9 1/2
11
9
4 3/4 dia
2 1/4
2 3/8
2 3/8 dia
13
4 1/4 dia
10 1/2 dia
14 1/4 dia
12 dia

BLOCK FOR 10-TON CRANE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Crane Hook	Wro't Iron	1	—
2	Side Plates	Mild Steel	2	17″ × 14½″ × ¼″
3	,, Links	,,	2	14½″ × 4″ × ⅝″
4	Suspension Bar	Wro't Iron	1	—
5	Hex. Nuts for Bar	Mild Steel	2	1¼″ × ⅝″ thick
6	Ball Washers	Hardened Steel	2	4⅜″ dia. ⅜″ thick
7	,, Cage	Cast Iron	1	5″ dia. ⅜″ thick
8	Steady Pins for Washers	Mild Steel	2	½″ dia. ¾″ long
9	Circular Nut	,,	1	4½″ dia. tapped 2½″
10	Split Pin	,,	1	¼″ × 3½″

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
11	Pulleys	Cast Iron	2	856
12	Bushes for Pulleys	Gun Metal	2	857
13	Spindle for Pulleys	Mild Steel	1	1¾″ dia. 12¾″ long
14	Hex Nuts for Pulleys	,,	2	1¼″ × ⅝″ thick
15	Stay Bolts	,,	2	⅝″ × 11½″
16	Ferrules for Stay Bolts	Wro't Iron	2	¾″ pipe 9½″ long
17	Hex. Nuts for Stay Bolts	Mild Steel	4	¾″
18	Balls	Hardened Steel	8	¾″ dia.
19	Feathers for Pulley Spindle	Mild Steel	2	⅜″ × 1″ × ¾″
20	Grub Screws fixing Bushes in Pulleys	,,	2	¼″ × ¼″

The arrangement of the Hook, Pulleys, etc., for a 10-ton Crane is illustrated on the plate facing this page. The hoisting is by means of flexible steel-wire ropes, which pass round the pulleys (**11**) and the barrel of the crab. The spindle (**13**) on which the pulleys revolve is made a tight fit in the side plates (**2**) and links (**3**), and is prevented from rotating with the pulleys by means of short keys or feathers (**19**).

The bushes (**12**) are a tight fit in the pulleys, and are fixed thereto by means of grub screws, which are half in the bush, and half in the pulley, there being one grub screw to each pulley.

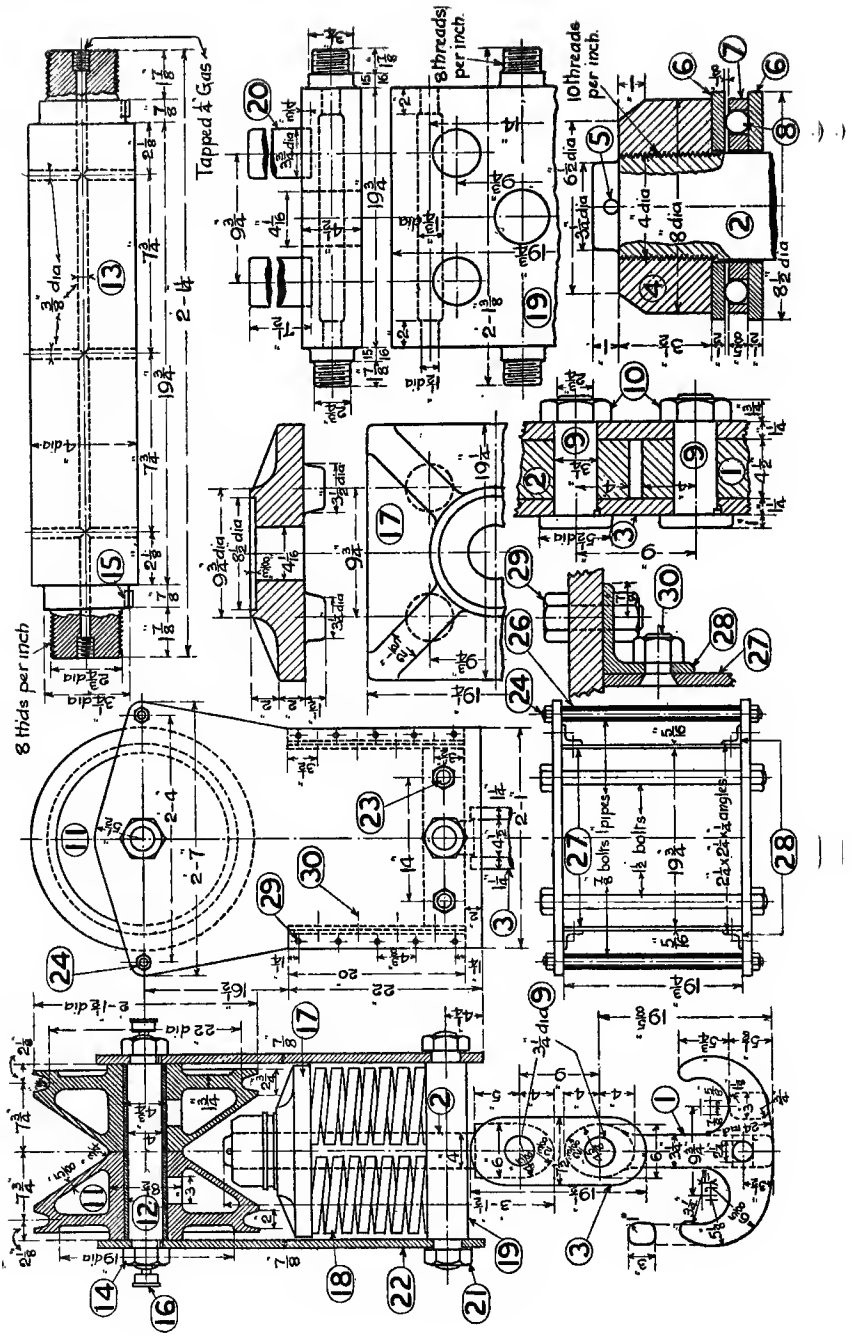
It will be noted that the shank of the hook is carried on ball washers. This enables the hook to be twisted about with the utmost ease.

Example 14.—Make separate detail working drawings of each of the following items: **1, 2, 3, 4, 9, 11, 12,** and **13.**

Example 15.—Design a similar arrangement of hook, pulleys, etc., for a 15-ton crane.

Example 16.—Trace the drawing made to Example 14.

PLATE No. 11


8 threads per inch
Tapped 4" Gas
8 threads per inch.
10 threads per inch.
2 bolts
1 pipes
1 bolts
2½x2½x½ angles

SPRING-RELIEVING BLOCK FOR 40-TON CRANE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Hook	Mild Steel	1	—
2	Eye Bolt	,,	1	$37\frac{3}{8}$″ long
3	Shackles	,,	2	$7\frac{1}{2}$″ × $1\frac{1}{2}$″ × $19\frac{1}{2}$″
4	Circular Nut for Eye Bolt. Tapped 4″ dia. 10 Th'ds per In.	,,	1	$3\frac{1}{2}$″ thick 8″ dia.
5	Split Pin	,,	1	$\frac{9}{16}$″ dia. $5\frac{1}{2}$″ long
6	Ball Washers	Hardened Steel	2	$\frac{1}{2}$″ thick $8\frac{1}{2}$″ dia.
7	Ball Cage	Cast Iron	1	$\frac{5}{8}$″ thick 8″ dia.
8	Balls	Hardened Steel	22	$\frac{3}{4}$″ dia.
9	Pin Bolts for Shackles	Mild Steel	2	$3\frac{1}{4}$″ × 9″
10	Hex. Nuts for Pin Bolts ($1\frac{3}{4}$″ thick)	,,	2	$2\frac{3}{4}$″
11	Sheaves	Cast Iron	2	356
12	Bushes for Sheaves	Gun Metal	2	357
13	Spindle for Sheaves	Mild Steel	1	4″ dia. $25\frac{1}{4}$″ long
14	Hex. Nuts for Spindle ($1\frac{3}{4}$″ thick)	,,	2	$2\frac{3}{4}$″
15	Feathers for Spindle	,,	2	$\frac{1}{8}$″ square $\frac{3}{4}$″ long
16	Stauffer Lubricators	—	2	No. 6
17	Spring Top Plate	Cast Iron	1	358
18	Helical Springs (13″ long uncompressed)	Spring Steel	4	$8\frac{5}{8}$″ outs. 4″ ins.
19	Suspension Plate	Mild Steel	1	—
20	Spring Pillars	,,	4	$3\frac{3}{4}$″ dia. $7\frac{1}{2}$ long
21	Hex. Nuts ($1\frac{3}{4}$″ thick)	,,	2	$2\frac{3}{4}$″
22	Side Plates	,,	2	44″ × 31″ × $\frac{7}{8}$″
23	Hex. Hd. Bolts with Hex. Nuts	,,	2	$1\frac{1}{2}$″ dia. $23\frac{1}{4}$″ long
24	Rope Guard Stays	,,	2	$\frac{7}{8}$″ dia. $23\frac{1}{2}$ long
25	Hex. Nuts for Stays	,,	2	$\frac{7}{8}$″ standard
26	Ferrules for Stays	Wro't Iron	2	1″ pipe $19\frac{3}{4}$″ long
27	Enclosing Plates	Mild Steel	2	20″ × $19\frac{3}{4}$″ × $\frac{5}{16}$″
28	Angles for Plates	,,	4	$2\frac{1}{4}$″ × $2\frac{1}{4}$″ × $\frac{1}{4}$″ × 20″
29	Hex. Hd. Bolts with Hex. Nuts	,,	20	$\frac{5}{8}$″ × $1\frac{3}{8}$″
30	C't's'k Hd. Bolts with Hex. Nuts	,,	16	$\frac{5}{8}$″ × $1\frac{1}{4}$″
31	Grub Screws for Sheaves and Bushes	,,	2	$\frac{3}{8}$″ × $\frac{1}{8}$″

Details of a Crane, Hook, etc, suitable for a 40-ton Crane are shown in the illustration. The hook (1) is suspended on plates (17) and (19), between which four compression springs (18) are arranged. This is to enable the crane to be used for handling the work done in heavy forging machines and presses, the springs relieving the ropes of the sudden shocks at the moment the press comes into operation. The springs deflect ·3″ per ton load, the section of the material being rectangular, $2\frac{5}{16}$″ × $1\frac{3}{16}$″.

The bushes (12) in the sheaves (11) are fixed thereto by means of grub screws (one screw per bush), which are put in endways, half in the bush and half in the sheave.

The spindle (13) is prevented from turning in the end plates by the short feathers (15). Grease from the lubricators (16) is forced through the holes in the spindle to the surface on which the sheaves revolve.

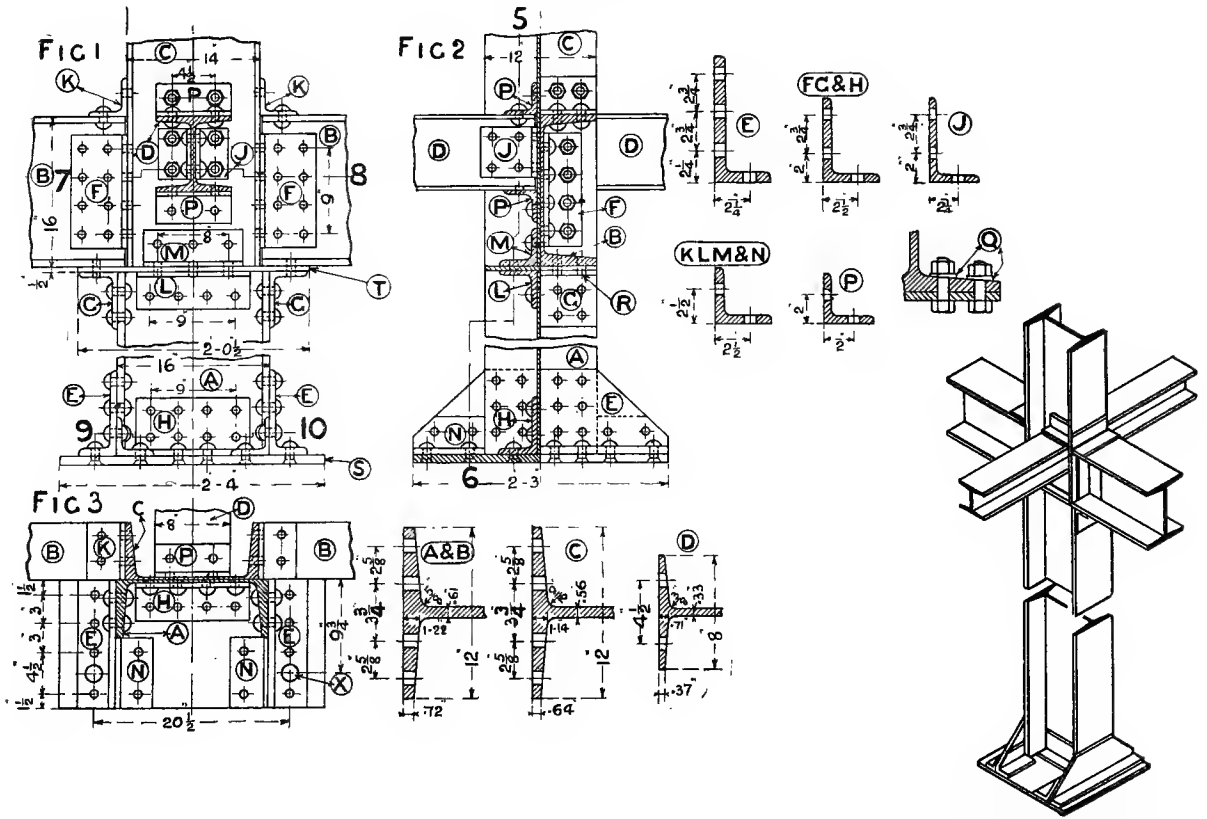
EXAMPLE 17.—Separate detail working drawings are to be made of each of the following items: 1, 2, 11, 19, and 22.

EXAMPLE 18.—Make a complete general arrangement showing all the parts assembled in their correct working positions.

Show two elevations and a plan. Let one elevation be partly in section similar to the elevation given on the illustration.

Make the upper half of the plan an outside view, and the lower half a view with the sheaves, bushes, and spindle removed.

PLATE No. 12



STEEL STANCHION

Ref. Letter.	Description.	Material.	Number Reqd.	Pattern No. or Size.
A	Beam	Steel	1	16″ × 12″ × 107 lbs./ft.
B	,, ...	,,	2	16″ × 12″ × 107 lbs./ft.
C	,, ...	,,	1	14″ × 12″ × 96 lbs./ft.
D	,, ...	,,	2	8″ × 8″ × 37 lbs./ft.
E	Angles 27″ long . .	,,	2	9″ × 4″ × $\frac{3}{8}$″
F	,, 12″ ,, . .	,,	4	6″ × 4″ × $\frac{5}{8}$″
G	,, 12″ ,, . .	,,	2	6″ × 4″ × $\frac{5}{8}$″
H	,, 12″ ,, . .	,,	2	6″ × 4″ × $\frac{7}{8}$″
J	,, 5½″ ,, . .	,,	4	6″ × 3½″ × ½″

Ref. Letter.	Description.	Material.	Number Reqd.	Pattern No. or Size.
K	Angles 12″ long . .	Steel	2	4″ × 4″ × $\frac{5}{8}$″
L	,, 12″ ,, .	,,	2	4″ × 4″ × $\frac{5}{8}$″
M	,, 10½″ ,, . .	,,	2	4″ × 4″ × $\frac{5}{8}$″
N	,, 7½″ ,, . .	,,	4	4″ × 4″ × $\frac{5}{8}$″
P	,, 8″ ,, . .	,,	4	3½″ × 3½″ × ½″
Q	Bevel Washers . .	,,	—	$\frac{7}{8}$″
R	Hex. Hd. Bolts and Nuts	,,	—	$\frac{7}{8}$″
S	Base Plate . . .	,,	1	28″ × 27″ × $\frac{7}{8}$″
T	Cover Plate . .	,,	1	24½″ × 12″ × ½″

A Stanchion built up of broad flange beams is illustrated on the plate facing this page, such stanchions being a common feature in the construction of modern buildings.

Fig. 1 is a side elevation, Fig. 2 an end elevation. The left-hand half of Fig. 2 is a section taken conventionally. Fig. 3 is a conventional plan, the upper half showing the beam (C) and its connections to beams (B) and (D), the lower half showing beam (A) and its connections to the base plate (S).

Enlarged views of portions of the beam sections are given, and from these may be obtained the spacing of the holes for the bolts and rivets. The hole spacings in the angles are also indicated in the separate sketches of these sections. All the bolts and rivets are $\frac{7}{8}$″ diameter. Where bolt heads or nuts come on the tapered faces of the beam flanges they are bedded thereon by means of special washers (Q) which taper in their thickness.

The holes in the base plate (marked X) are for 1½″ foundation bolts, and are 1$\frac{5}{8}$″ diameter.

Example 19.—Make a drawing to a scale of 3″ = 1′ as follows:—

(*a*) A side elevation, the left half of which is to show a section on the line **5-6**, the right half being an outside view.

(*b*) An end elevation, outside view.

(*c*) A plan, the upper half being a section on line **7-8** and the lower half a section on line **9-10**.

Make a complete list of the bolts, rivets, and washers used in the construction.

Use the narrow edge of the drawing paper as the top of the sheet.

SECTION II

TOOTHED GEARING

SECTION II

THE five following plates illustrate the construction of Cycloidal and Involute Curves, and their application to the shape of the teeth of gear wheels, and give illustrations of various forms of gear wheels and pinions.

Before proceeding with the examples given in the text accompanying these plates, the student should familiarise himself with the following points concerning gearing generally.

Pitch of Teeth.—There are two ways of indicating "pitch" of teeth. "Circular pitch" is specified in inches, and is the distance between corresponding points of two consecutive teeth **measured round** the pitch circle, i.e. circular pitch $= \frac{\pi \times D}{N}$ where D = diameter of pitch circle and N = number of teeth.

Diametral or diametrical pitch is expressed as a numeral, and indicates the **number of teeth per inch of pitch circle diameter,** i.e. diametral pitch $= \frac{N}{D}$. Circular pitch may be converted to diametral pitch, thus: $CP = \frac{\pi}{DP}$, and similarly diametral pitch is converted to circular pitch, thus: $DP = \frac{\pi}{CP}$.

The usual proportions for the teeth of wheels are as follows:—

Where CP = circular pitch in inches.
,, DP = diametrical pitch.
,, H = height of tooth outside the pitch circle.
,, D = depth ,, ,, inside ,, ,, ,,
,, T = thickness of tooth measured round the pitch circle.
,, S = width of space between teeth ,, ,, ,, ,,
,, OD = outside diameter.
,, N = number of teeth.

For Machine Cut Gear.		For Unmachined Gears.
$H = \cdot3183CP$	or $\frac{1}{DP}$.	$H = \cdot3CP.$
$D = \cdot3683CP$	or $\frac{1\cdot157}{DP}$.	$D = \cdot4CP.$
$T = \cdot5CP$	or $\frac{1\cdot5708}{DP}$.	$T = \cdot46CP.$
$S = \cdot5CP$	or $\frac{1\cdot5708}{DP}$.	$S = \cdot54CP.$
$OD = \frac{(N + 2) \times CP}{\pi}$	or $\frac{N + 2}{DP}$.	

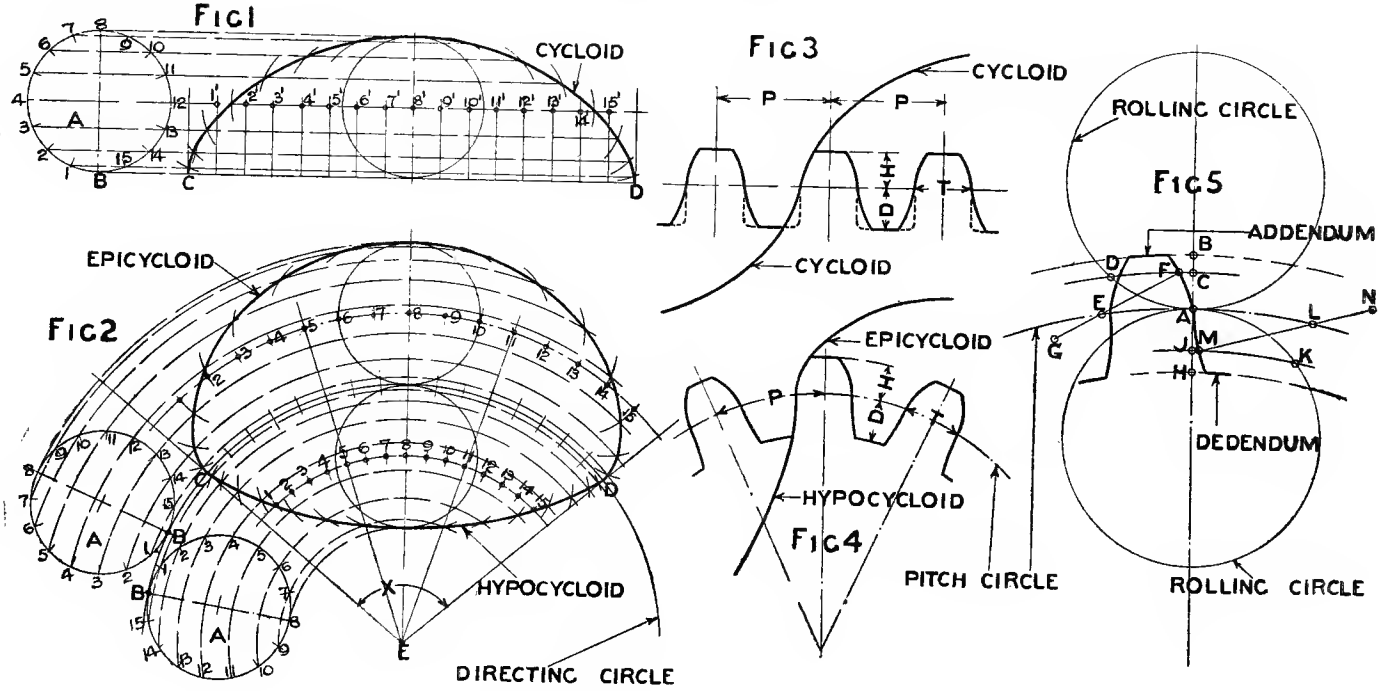
Involute Teeth.—This is the shape of tooth most generally used, and, though the pressure angle or angle of obliquity is commonly $14\frac{1}{2}°$ or 15°, and the proportions given above the ones most commonly adopted, the stubbed involute tooth, having a pressure angle of 20°, is quite frequently used, and the usual proportions for this tooth are as follows:—

$$H = \cdot25CP \quad \text{or } \frac{\cdot7854}{DP},$$

$$D = \cdot31416CP \text{ or } \frac{\cdot9424}{DP},$$

the other proportions being as before.

PLATE No. 13


FIG 1
CYCLOID
A
B
C
D
FIG 2
EPICYCLOID
HYPOCYCLOID
DIRECTING CIRCLE
FIG 3
CYCLOID
P
P
H
D
T
CYCLOID
FIG 4
EPICYCLOID
P
D
H
T
HYPOCYCLOID
PITCH CIRCLE
ROLLING CIRCLE
FIG 5
ADDENDUM
DEDENDUM
ROLLING CIRCLE

CYCLOIDAL TEETH FOR GEAR WHEELS

When a circle is rolled along a straight line any fixed point in the circumference of the circle generates a CYCLOID.

Let A (Fig. 1) be the circle, B the fixed point, and CD the straight line. Make CD = the circumference of the circle. Imagine the circle to be placed on CD with point B coinciding with point C. If the circle be rolled once round, B will coincide with D, since CD = the circumference. During the process of rolling, B follows the path indicated by the thick line. This path is the **Cycloid.** To draw the curve, divide the circumference of the circle and CD into the same number of equal parts. Draw the horizontal projectors from the points in the circumference and with centres 1′, 2′, 3′, 4′, etc., and radius equal to radius of circle, describe the arcs intersecting the corresponding projectors.

When a circle is rolled along the outside of another circle (called the directing circle), any fixed point in the circumference of the rolling circle generates an EPICYCLOID.

If the circle be rolled along the inside of the directing circle the path traced by the fixed point in the rolling circle is a HYPOCYCLOID.

Fig. 2 shows how both these curves may be obtained. A is the rolling circle, B the fixed point, and CD an arc of the directing circle **equal in length to the circumference of the rolling circle.**

The angle X in degrees $= \frac{360 \times Y}{Z}$ where Y = diameter of rolling circle and Z = diameter of directing circle.

The arc CD and the rolling circle are divided into the same number of equal parts and points in the curve obtained as for the cycloid, but in this case, instead of horizontal projectors, circular projectors concentric with the directing circle are used.

Figs. 3 and 4 show the application of these curves to the teeth of racks and wheels, the cycloid to rack teeth and the epicycloid and hypocycloid to wheel teeth. In the case of racks gearing with one wheel only the flanks of the teeth are made straight as shown by the dotted lines, Fig. 3. In setting out teeth of wheels the pitch circle becomes the directing circle. The rolling circle diameter is usually taken as $\frac{12 \times CP}{2\pi}$ where CP = circular pitch in inches.

Professor Unwin's method of approximating the shape of cycloidal teeth is illustrated in Fig. 5. Describe

the pitch, addendum, dedendum, and rolling circles. Make AC = $\frac{2}{3}$AB. Describe arc CD concentric with pitch circle. Make arc AE = arc AD. With centre E and radius equal to chord AD mark point F in arc CD. F is a point in the true epicycloid. Join FE, and on FE produced, find, by trial, point G from which to describe arc AF. AF produced to the addendum circle forms the face of the tooth. Make AJ = $\frac{2}{3}$AH. Describe arc JK concentric with pitch circle. Make arc AL = arc AK. With L as centre and a radius equal to chord AK mark point M in arc JK. M is a point in the true hypocycloid. Join ML, and on ML produced, find, by trial, point N from which to describe arc MA. MA produced to the dedendum circle forms the flank of the tooth.

EXAMPLE 20.—Draw the three cycloidal curves generated by a 2″ diameter rolling circle. For the epicycloid and the hypocycloid make the directing circle $3\frac{1}{2}$″ radius.

EXAMPLE 21.—On a pitch circle of 5″ radius set out two teeth of $1\frac{1}{2}$″ pitch by the method shown in Fig. 5.

PLATE No. 14

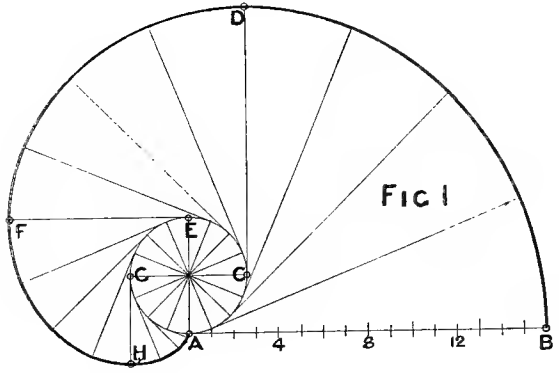


FIG 1

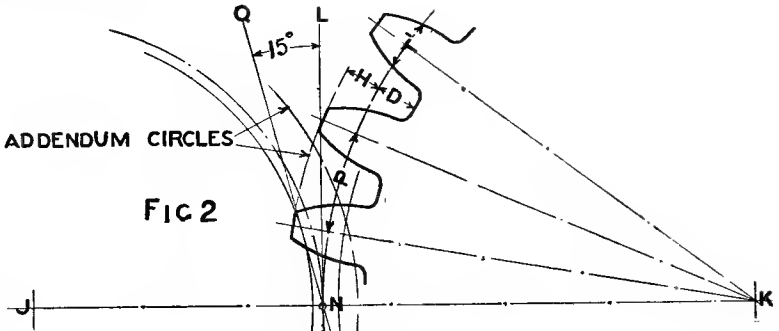


FIG 2

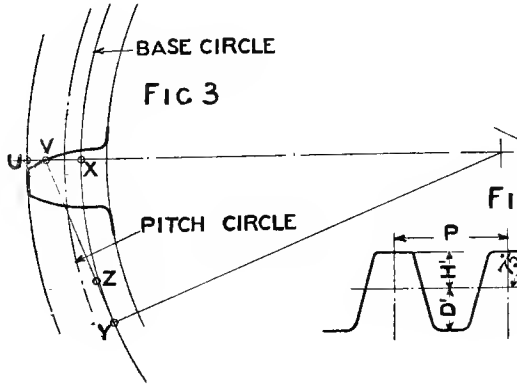


FIG 3

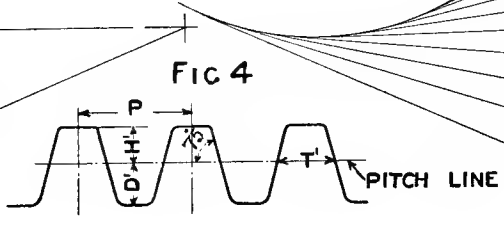


FIG 4

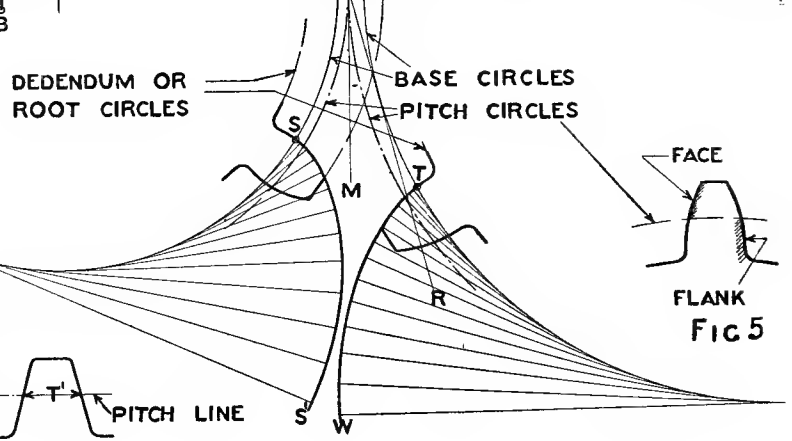


FIG 5

INVOLUTE TEETH FOR GEAR WHEELS

The Involute of a Circle is traced by the free end of a thread as the thread is unwound from the circle. This is illustrated by Fig. 1.

AB = the circumference of the circle, and, when the thread is entirely unwound, it occupies the position AB; when three-fourths unwound the free end is at D; when half unwound the free end is at F, and so on. The curve AHFDB is the involute of the circle AGEC.

To construct the curve, make AB = circumference of circle. Divide AB and the circle into the same number of equal parts. Draw tangents to the circle at the various points, and mark the length of each tangent by measurement on AB, making GH = $\frac{1}{4}$AB, FE = $\frac{1}{2}$AB, and so on. The curve may then be drawn through the points obtained.

Fig. 2 illustrates how the involute curve is used for determining the shape of gear wheel teeth. J and K are the centres of two gear wheels, JK being the line of centres and N the pitch point. LM is the "common tangent" to the two pitch circles, QR being the path of contact, making an angle of 15° to the common tangent. This angle is termed the "angle of obliquity," and the line QR is tangent to two circles which are called "base circles". It is the **involute of the base circle** which is used for determining the shape of the teeth. Only a short length of the curve is used, i.e. the part extending from the base circle to the addendum circle. The portion of tooth inside the base circle may be shaped by a continuation of the curve as shown or it may be made "radial".

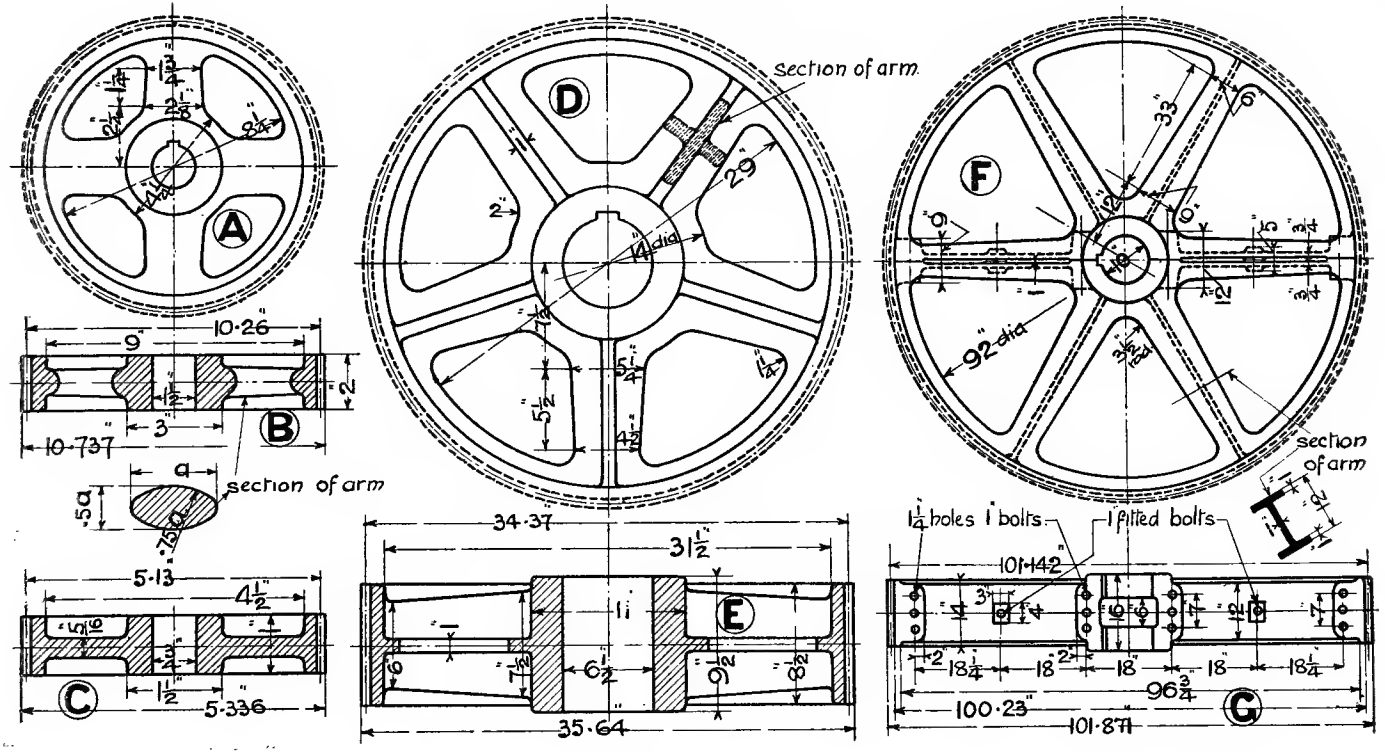
Fig. 3 shows Professor Unwin's method of approximating the shape of an involute tooth, the procedure being as follows: Describe the pitch, addendum, and dedendum circles, and determine the diameter of base circle by drawing the angle of obliquity as in Fig. 2. Make UV = $\frac{1}{3}$UX and draw VY tangent to the base circle. Make VZ = $\frac{3}{4}$VY. Z is the centre from which may be described the arc passing through V.

Fig. 4 shows the shape of the teeth of a rack suitable for use with wheels having involute teeth. The teeth of a worm gearing with a worm wheel having involute teeth are also shaped as in Fig. 4.

EXAMPLE 22.—Draw the involute of a 2″ diameter circle.

EXAMPLE 23.—On a pitch circle of 5″ radius set out two teeth of 3s diametrical pitch by the method indicated by Fig 3.

PLATE No. 15


A
B
C
D
E
F
G
section of arm
10·26
9"
10·737
3"
2"
a
·5a
·250
5·13
4½"
5·336
1½"
34·37
31½"
35·64
29"
14" dia
92" dia
33"
1¼ holes 1" bolts
1" fitted bolts
101·142
100·23"
101·871
96¾"
18"
18¼"

SPUR WHEELS

Illustrations of Spur Wheels having different forms of arms are shown on the plate facing this page.

Figs. A and B show a wheel with 43 teeth, $\frac{3}{4}''$ circular pitch, 2″ face, having four arms of segmental section.

Fig. C shows a section of a wheel with 43 teeth, $\frac{3}{8}''$ circular pitch, 1″ face, having a central disc in lieu of arms. Both these types of wheels are commonly used for light work, as in small machine tools, etc.

Figs. D and E show a wheel of 54 teeth of 2″ pitch and $8\frac{1}{2}''$ face, having five arms of cruciform section. This is a popular section of arm for gears transmitting considerable power, and is well adapted for wheels having wide faces.

Figs. F and G show the construction of a very large gear wheel, having 177 teeth of $1\frac{3}{4}$ diametrical pitch, the teeth being stubbed involute, and double helical.

The arms are of the girder section indicated in the auxiliary view, this being the usual form adopted in the case of very heavy gearing. The wheel is made in halves, and it will be noted that the arms shown across the horizontal centre are modified in shape for the purpose of connecting the two halves together.

In making a **working drawing** of a gear wheel it is not usual to **show** the shape of the teeth. This is merely specified, and, if involute, the angle of obliquity or pressure angle should be given. If cycloidal teeth are used the rolling circle diameters should be stated.

EXAMPLE 24.—Make a working drawing of a gear wheel similar to the one shown by Figs. A and B, but to the following particulars: Number of teeth, 47; circular pitch, $\frac{7}{8}''$; breadth of face, $2\frac{1}{2}''$; length through hub, 3″; diameter of shaft, $1\frac{3}{4}''$; diameter of hub, $3\frac{1}{2}''$; thickness of rim below the teeth, $\frac{7}{16}''$; number of arms, 4. Section of arm as shown, "a" at the rim being 2″ and at the hub $2\frac{1}{2}''$.

EXAMPLE 25.—Make a working drawing of a gear wheel similar to the one shown by Figs. D and E, but to the following particulars: Number of teeth, 72; diametrical pitch, 3s; breadth of face, $4\frac{1}{4}''$; diameter of shaft, $3\frac{3}{4}''$; diameter of hub, $7\frac{1}{2}''$; length through hub, $5\frac{1}{4}''$; thickness of rim below teeth, $\frac{9}{16}''$; number of arms, 6; thickness of arm, $\frac{9}{16}''$; width of arm at rim, $3\frac{1}{2}''$; width at hub, $4\frac{1}{2}''$.

PLATE No. 16

19·098 dia
7·321
5·888 centres
5 dia
24 dia
20¼ dia
4½
1½
3¾
3¾
3⅜
3⅜
28 dia
10 dia
24 dia
5¾
3½
5¾
A
B
C
C
D

INTERNAL SPUR GEAR

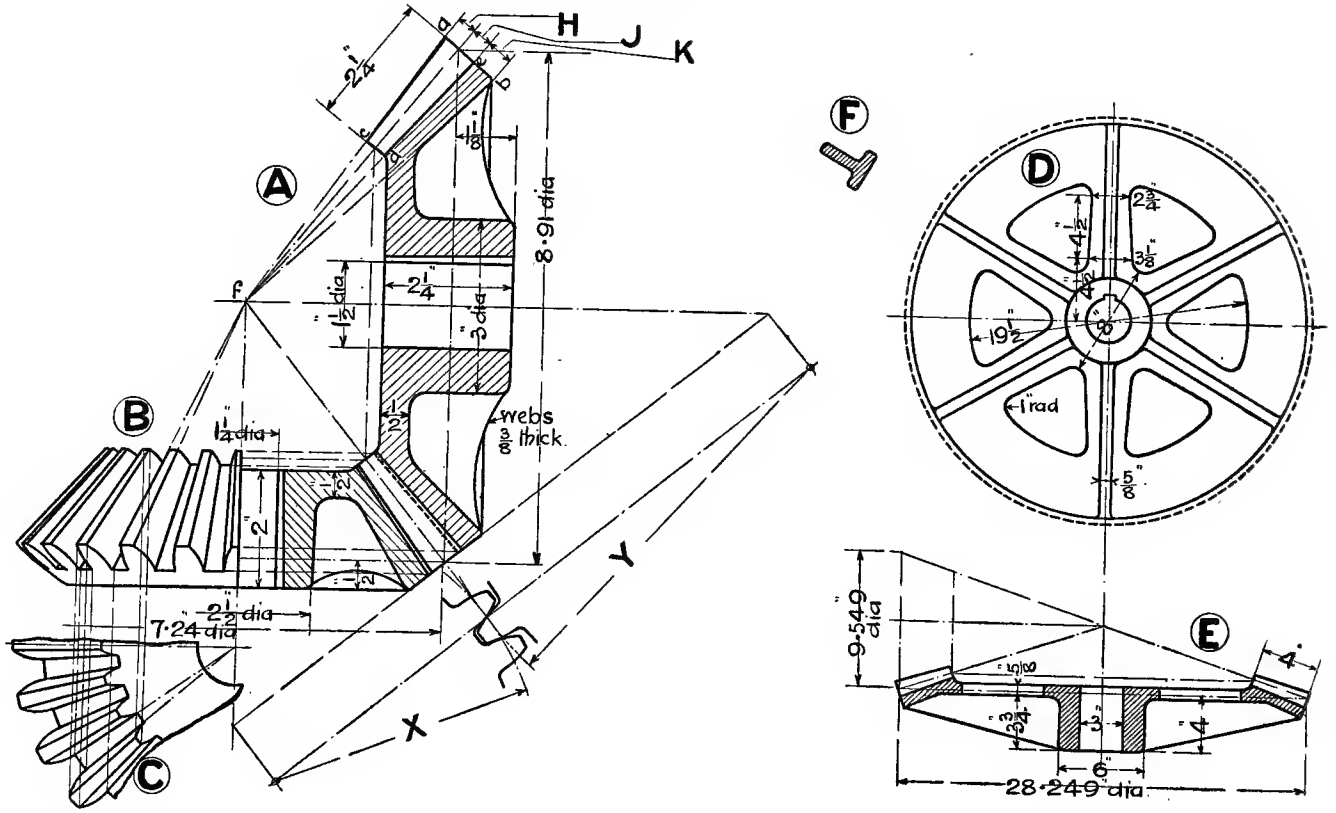
An Internal Spur Wheel (A) is depicted in the illustration facing this page, a small portion only of the wheel being shown. The pinion indicated is of special construction, the materials employed being intended to eliminate noise when the gear is running. The pinion consists of a central brass bush (B) having an end plate cast solid with it. Threaded on to this bush are layers of special material (C), which may be raw hide, or compressed paper, or cotton fabric. When in position on the bush this material is subjected to enormous pressure, the loose end plate (D) slipped on, and the whole riveted together in the manner indicated. The teeth are then cut in the usual way. It will be noted that the width of the teeth in the "silent" material of the pinion is greater than the width of the metal teeth in the wheel, the brass end plates of the pinion not coming into contact with the wheel at all. In the example shown the spur wheel takes the form of a fly-wheel, and such an arrangement is suitable for coupling up a motor to a pump or compressor.

With internal gears both shafts run in the same direction, and the shaft centres are much closer together for the same gear ratio than they are with the ordinary external gears. The gearing is also more or less self-protected. The student will notice that the form of the internal tooth on the wheel is practically the same as the form of the "space" on an external gear.

EXAMPLE 26.—Make a drawing of a similar wheel and pinion, working to the following dimensions: Number of teeth—pinion, 20; wheel, 54; pitch, 3s diametrical; breadth of face of teeth, 4″; fly-wheel, 23″ diameter, $6\frac{1}{4}$″ wide; shafts as indicated.

The pinion shown in the illustration has 20 teeth and the wheel 60, the circular pitch being 1″.

PLATE No. 17


A
B
C
D
E
F
H
J
K
X
Y
F
2¼"
1⅛"
8·91 dia
1½ dia
2¼"
3" dia
1½"
webs ⅜ thick
1¼ dia
2"
2½ dia
7·24 dia
4½"
2¾"
3⅜"
⅝"
19½"
1" rad
9·549 dia
4"
⅝"
¾"
3"
4"
6"
28·249 dia

A small bevel wheel and pinion are shown at A and B respectively. The wheel is shown completely in section, the pinion being shown half in section and half in outside elevation. The wheel has 32 teeth and the pinion 26, the circular pitch being $\frac{7}{8}''$, and the breadth of face $2\frac{1}{4}''$.

It should be noted that in bevel gears the pitch is always measured on the largest diameter of the pitch cone.

The pitch cone is indicated in the illustration by the chain dotted lines, the largest diameter of cone for the wheel being $\frac{32 \times \cdot 875''}{\pi} = 8 \cdot 91''$ and for the pinion $\frac{26 \times \cdot 875''}{\pi} = 7 \cdot 24''$.

To set out a pair of bevel wheels the procedure is as follows:—

First set out the two pitch cones. Then mark the "breadth of face" on the pitch cones and draw the lines **ab**, **cd**, showing the breadth of the tooth. These lines are at right angles to the pitch cone.

On **ab** mark the height of tooth above the pitch cone, the depth of tooth below the pitch cone, and the thickness of the rim below the bottom of the tooth. H = ·3183CP, J = ·3683CP, and K = ·5CP, CP being the circular pitch. Now draw the lines **af**, **ef**, **bf**, radiating from the apex of the pitch cones. The remainder of the sectional view may then be proceeded with.

If it is required to show an outside view such as that indicated by the left half of the view of the pinion, it is necessary to first draw a plan looking on the face of the teeth. Such a plan is partially shown at C. By vertical projectors from this plan and horizontal projectors from the sectional half view of the pinion the necessary points may be obtained for showing the teeth in outside elevation in the manner indicated in the illustration.

The radius of pitch circle on which the **shape** of the teeth is determined is given by the dimension Y for the wheel and by dimension X for the pinion.

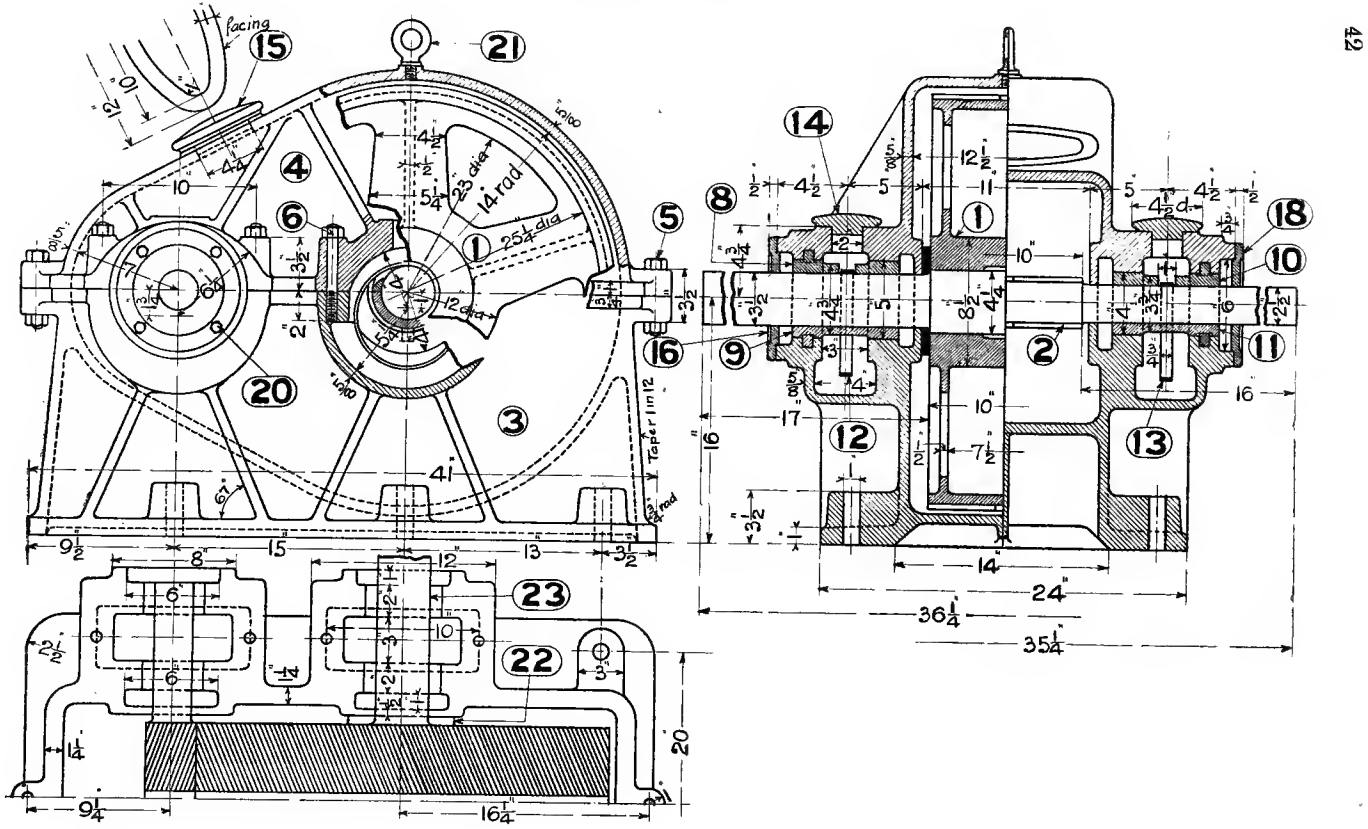
A drawing of a bevel wheel with arms is shown by figures D and E, a section of the arm being shown at F.

In this case the pinion is not shown, only its pitch cone being indicated. The arms of the wheel are of Tee section, a form particularly well suited to bevel wheels. The wheel shown has 71 teeth of $1\frac{1}{4}''$ circular pitch and 4″ face. The pinion has 24 teeth.

EXAMPLE 27.—Make a drawing of the wheel and pinion shown at D and E, completing the design of the pinion. The pinion may be similar in form to the wheel A, but suitable for a shaft 2″ diameter.

Determine the dimensions X and Y in the manner indicated above, and then set out the shape of the teeth of both wheel and pinion by the method indicated in Fig 3 on Plate No. 14.

PLATE No. 18


facing
15
21
4
6
5
1
20
3
16
9
2
14
8
18
10
11
12
13
17
23
22
Taper 1 in 12
41
36¼
35¼
24
14
16
20

DOUBLE HELICAL REDUCTION GEAR

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Double Helical Gear Wheel .	Cast Iron	1	1071
2	,, ,, Pinion and Shaft	Carbon Steel	1	Total length $35\frac{1}{4}''$
3	Casing (lower half) . . .	Cast Iron	1	1072
4	,, (upper half) . . .	,,	1	1073
5	Hex. Hd. Bolts and Nuts . .	Mild Steel	2	$\frac{5}{16}''$ × $4\frac{1}{4}''$
6	Studs (screwed 2″ and 1″) . .	,,	8	$\frac{5}{16}''$ × $6\frac{1}{4}''$
7	Hex. Nuts for Studs . . .	,,	8	$\frac{5}{16}''$
8	Large Bearing Bush (upper half)	Phosphor Bronze	2	1074
9	,, ,, ,, (lower half)	,,	2	1075
10	Small Bearing Bush (upper half)	,,	2	1076
11	,, ,, ,, (lower half)	,,	2	1077
12	Oil Rings 7″ outs. dia. $6\frac{5}{8}''$ ins. dia	Brass	2	$\frac{3}{16}''$ wide
13	,, ,, $6\frac{1}{2}''$ outs. dia. $6\frac{1}{8}''$ ins. dia.	,,	2	$\frac{3}{16}''$ wide
14	Inspection Covers for Bearings.	Cast Iron	4	1078
15	,, ,, ,, Casing .		1	1079
16	End Cover for Large Bearing bored $3\frac{15}{16}''$ dia.	,	1	1080
17	End Cover for Large Bearing Without Central Hole	Cast Iron	1	1080
18	End Cover for Small Bearing, bored $\frac{9}{16}''$ dia.	,,	1	1080
19	End Cover for Small Bearing Without Central Hole	,	1	1080
20	Hex. Hd. Set Bolts . . .	Mild Steel	16	$\frac{5}{16}''$ × 1″
21	Lifting Eye	,,	1	$\frac{5}{16}''$ screwed
22	Thrust Washers $\frac{1}{2}''$ thick . .	Phosphor Bronze	2	7″ dia. $3\frac{1}{2}''$ hole
23	Gear Wheel Shaft . . .	Mild Steel	1	$4\frac{1}{4}''$ × $36\frac{1}{2}''$
24	Key for Gear Wheel . . .	Key Steel	1	1″ × $\frac{11}{16}''$ × 10″
25	,, Coupling on Gear Wheel Shaft	,,	1	$\frac{7}{8}''$ × $\frac{7}{8}''$ × 6″
26	Key for Coupling on Pinion Shaft		1	$\frac{5}{8}''$ × $\frac{7}{16}''$ × 4″

Various conventional views of a Double Helical Reduction Gear complete with Housing are given on the plate facing this page.

The gearing indicated is capable of transmitting about 15 h.p., and the speed reduction is from 315 r.p.m. at the pinion shaft to 35 r.p.m. at the wheel shaft.

The pinion is of ·4 carbon steel, and is formed on the shaft itself. The wheel is of cast iron and has five arms of girder section.

The pinion has 15 teeth and the wheel 135, the pitch being 5s diametrical.

The width of face of teeth is 10″, addendum ·16″, dedendum ·2″.

Shape of tooth—20° involute; spiral angle, 23°.

The wheel is keyed to its shaft by the taper key, item **24**.

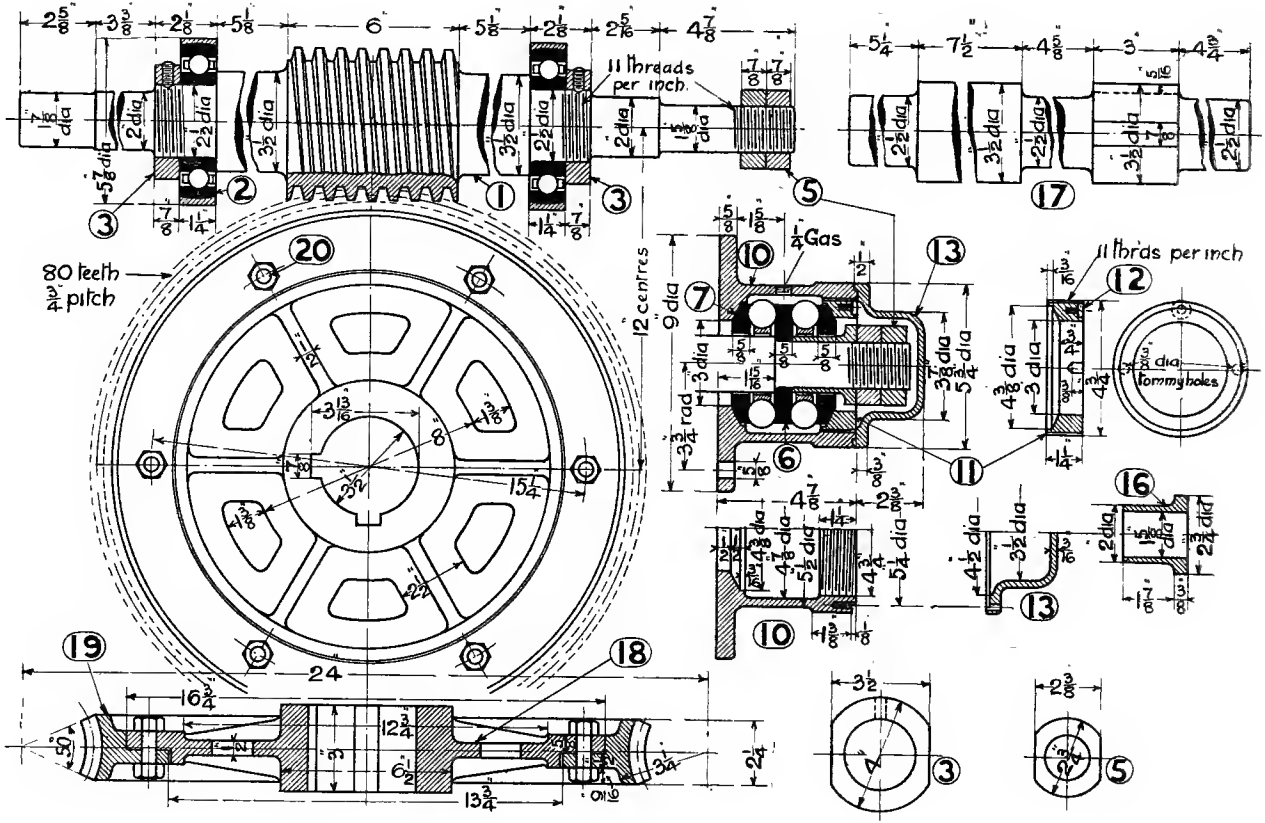
The bearing bushes are prevented from turning with the shaft by means of circular projections cast on and fitting into suitable recesses in the casing. These projections are $\frac{5}{8}''$ diameter × $\frac{1}{2}''$ long.

On the projecting ends of the pinion and worm-wheel shafts half-couplings are fixed by keys (items **25** and **26**) for coupling up the reduction gear to the shafts between which the power is being transmitted.

Example 28.—Make separate detail working drawings of each of the following items: **1, 2, 3, 4, 8, 9, 10, 11**, and **23**.

Example 29.—Make a general arrangement of the gearing and case complete. Show two sectional elevations and a complete plan. Design the two half-couplings and show them in position on their respective shafts.

PLATE No. 19


11 threads per inch.
80 teeth 4" pitch
12 centres
9 dia
1/4 Gas
11 thrds per inch
dia tommy holes
24
16 3/4
13 3/4
12 3/4
6 1/2
2 1/4
15 1/4
8
3 13/16
3 1/2
2 1/2
1 3/8
1 1/8
3/4
1/2
5/8
7/8
1/4
50°
1
2
3
4
5
6
7
10
11
12
13
16
17
18
19
20

Ref. Number.	Description.	Material.	Number Regd.	Pattern No. or Size.
1	Worm and Shaft	Mild Steel	1	—
2	Radial Ball-bearings	Hdnd. Steel	2	—
3	Lock Nuts for Bearings	Mild Steel	2	—
4	Grub Screws for Lock Nuts	,,	2	$\frac{3}{8}'' \times \frac{7}{8}''$
5	Lock Nuts for Thrust-bearing	,,	2	—
6	Thrust-bearing Central Ball Race	Hdnd. Steel	1	—
7	,, End Ball Race	,,	2	—
8	Ball Cages	Brass	2	—
9	Balls	Hdnd. Steel	18	1" dia.
10	Thrust-bearing Body	Cast Iron	1	184
11	,, ,, Lock Nut	,,	1	185
12	Thrust-bearing Lock Nut Locking Screw	Mild Steel	1	$\frac{5}{16}'' \times \frac{5}{16}''$
13	Thrust-bearing End Cover	Cast Iron	1	186
14	Stauffer Lubricator	Brass	1	No. 6
15	Cb. Hd. Screws	Mild Steel	4	$\frac{1}{4}'' \times 1''$
16	Sleeve	,,	1	—
17	Worm-wheel Shaft	,,	1	—
18	,, Hub	Cast Iron	1	187
19	,, Rim	Phosphor Bronze	1	188
20	Hex. Hd. Bolts and Nuts	Mild Steel	6	$\frac{1}{2}'' \times 1\frac{3}{4}''$
21	Keys (worm wheel to shaft)	Key Steel	2	$\frac{7}{8}'' \times \frac{5}{8}'' \times 3''$

Hoisting Gear as used for Goods and Passenger Electric Lifts is shown on this plate, the Housing for same being shown on the plate following.

The gearing indicated in the illustration is capable of hoisting a total load of 15 cwts. at a speed of about 80′ per minute, the speed of the worm shaft being 700 r.p.m.

It will be noted that the worm is cut out of the solid steel shaft and that the worm wheel has a phosphor bronze rim in which the teeth are cut. The lower portion of the housing, shown on Plate 20, is filled with lubricating oil, forming an oil-bath in which the worm wheel revolves.

The worm shaft is carried on radial ball-bearings, the end thrust in both directions being taken by a special double thrust-bearing. The worm-wheel teeth are 15° involute, and the section of the worm thread is as shown by Fig. 4 on Plate No. 14.

Example 30.—Make separate detail working drawings of each of the following items: **1, 18, 19.** Item **1** full size. Items **18** and **19** half size.

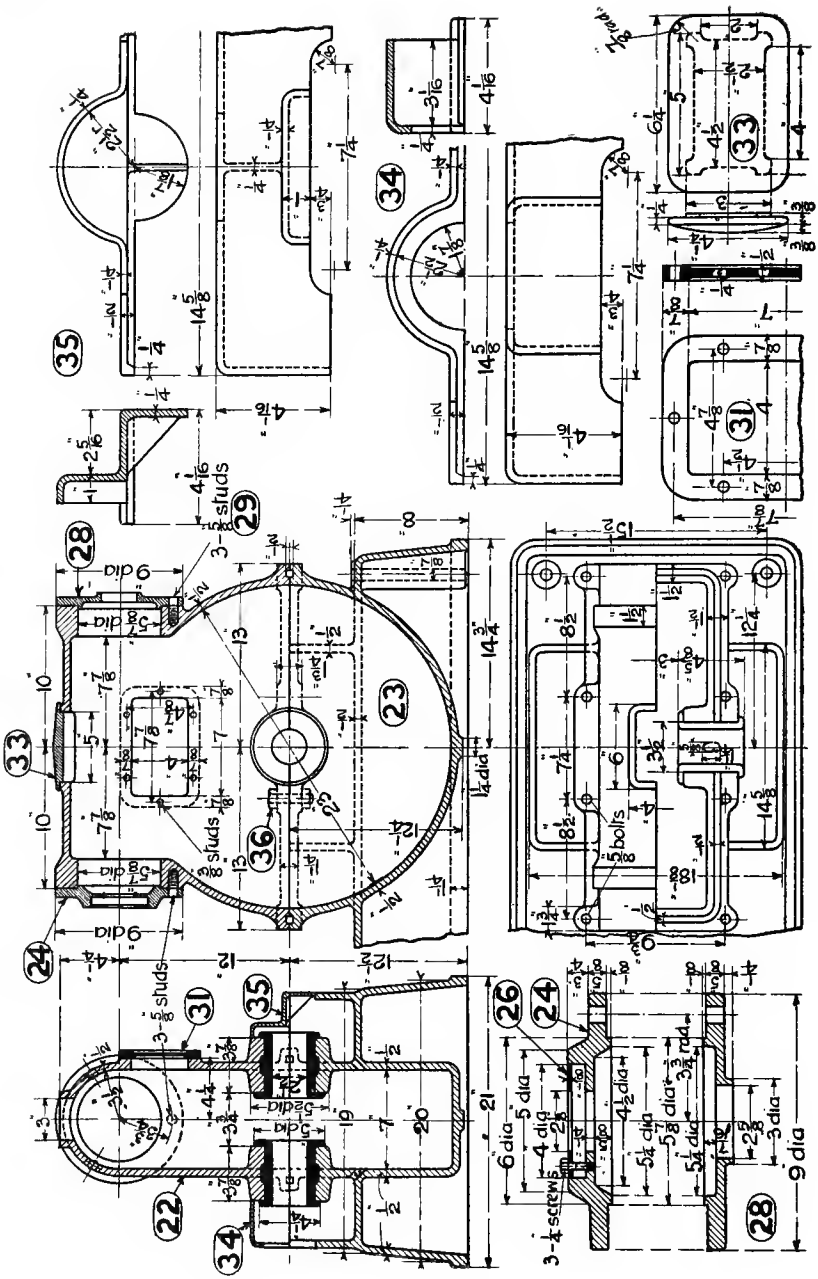
Example 31.—Make a working drawing, scale half size, of a similar worm wheel in which the centres of the worm and wheel are 12″ apart, the pitch of the teeth 1″, and the number of teeth in the wheel 60. Show the hub and rim assembled together as in the illustration.

Example 32.—Make a drawing of a double thrust-bearing showing all the parts assembled together as in the illustration, but working to the following dimensions:—

Diameter of shaft at end, $2\frac{1}{2}''$. Enlarged diameter, 3″. Over-all length of housing and cover, 11″. Housing flange, $12\frac{3}{8}''$ diameter $\frac{1}{16}''$ thick. Housing body, $8\frac{1}{2}''$ outside diameter. Balls, $1\frac{1}{2}''$ diameter; 9 in each row.

Scale, Full Size.

PLATE No. 20



HOUSING FOR HOISTING GEAR FOR LIFT

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
22	Upper Half of Housing . .	Cast Iron	1	189
23	Lower ,, ,, . .	,,	1	190
24	End Cap (left hand) .	,,	1	191
25	Washer for End Cap . .	Felt	1	4″ dia. $\frac{1}{2}$″ thick
26	Retaining Plate . .	Mild Steel	1	4″ dia. $\frac{1}{8}$″ thick
27	Hex. Hd. Set Bolts . . .	,,	3	$\frac{1}{4}$″ × $\frac{7}{8}$″
28	End Cap (right hand) . .	Cast Iron	1	192
29	Studs (screwed 1″ at each end)	Mild Steel	6	$\frac{5}{8}$″ × 2$\frac{1}{4}$″
30	Hex. Nuts . . .	,,	6	$\frac{5}{8}$″

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
31	Side Inspection Hole Cover .	Cast Iron	1	193
32	Studs (screwed $\frac{5}{8}$″ at each end)	Mild Steel	6	$\frac{5}{8}$″ × 1$\frac{1}{2}$″
33	Top Inspection Hole Cover .	Cast Iron	1	194
34	Dust Shield (front) . .	,,	1	195
35	,, (back) . .	,,	1	196
36	Hex. Hd. Bolts with Hex. Nuts	Mild Steel	8	$\frac{5}{8}$″ × 2$\frac{1}{2}$″
37	,, Nuts for Studs (item 32)	,,	6	$\frac{5}{8}$″
38	White Metal for Bearings .	—	—	—

On this plate is shown the Housing for the Hoisting Gear shown on the preceding plate.

The lower half of the housing casting (item **23**) is incompletely shown. The portion of this casting omitted from the illustration carries the motor and the brake drum attachments, but in so far as it concerns the housing of the gearing sufficient of the casting is shown.

The worm wheel running in an oil-bath causes a great splashing about of oil inside the housing, and special care has to be taken to prevent the oil from making its way through the joint between the upper and lower halves of the housing. The faces of the joint are carefully machined, and the groove which is cored in the casting all the way round the joint is packed with hemp well leaded to make an oil-tight joint.

Example 33.—Make a detailed working drawing, to as large a scale as possible, of item **22**, showing items **24** to **35** in their working positions. Show all the studs and other fasteners complete.

Example 34.—Make a general arrangement of the housing, with the gearing complete in its working position. Particulars of the gearing are to be obtained from Plate No. 19.

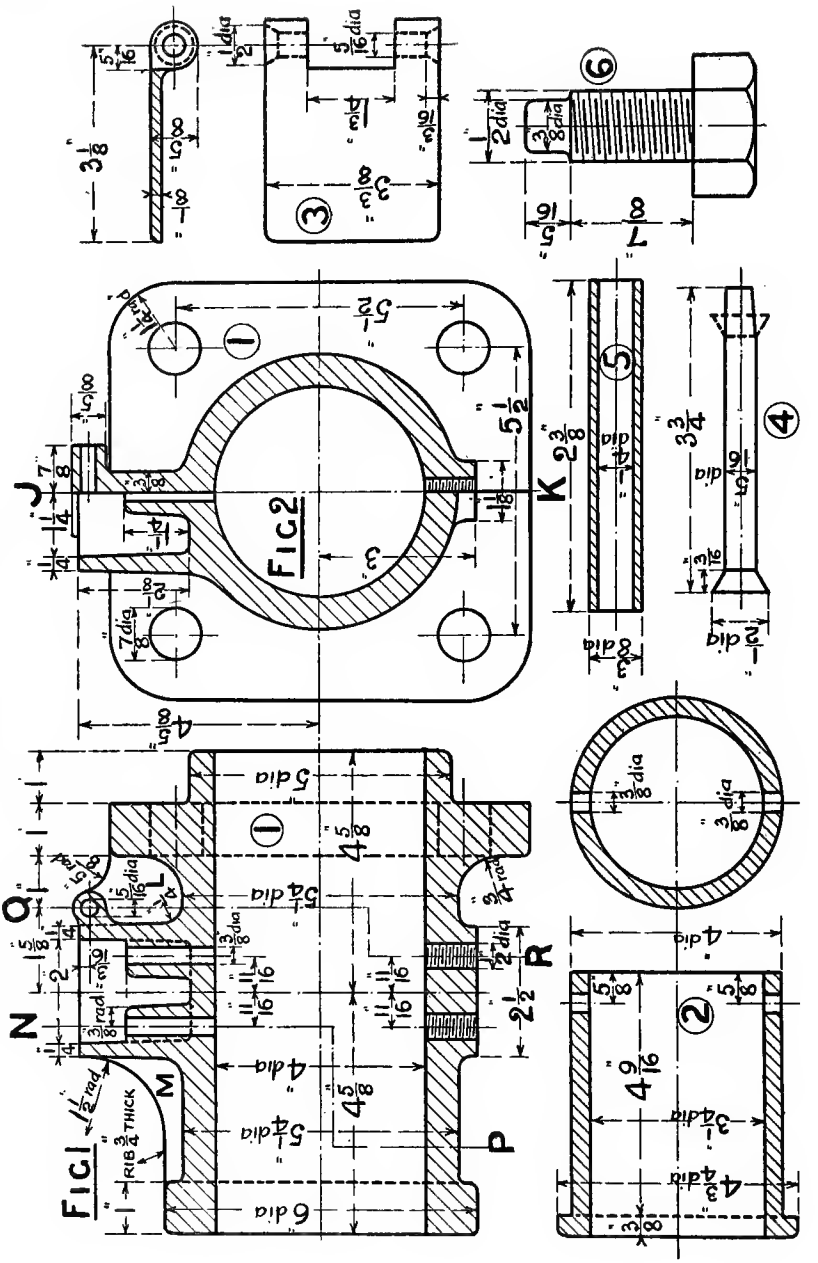
Show two elevations, each being partly or wholly in section, so as to indicate as many of the details as possible. Add a plan if space permits.

Example 35.—Trace the drawing made in Example 34.

SECTION III

DETAILS OF LOCOMOTIVES, OTHER STEAM ENGINES, AND STEAM GOVERNORS

PLATE No. 21


FIG 1
FIG 2
RIB 3/4" THICK
1 1/2" rad
3/8 rad
5 dia
5 1/4 dia
4 dia
6 dia
4 5/8
2 1/2
4 5/8 dia
7/8 dia
3 3/8 dia
3 dia
4 dia
4 9/16
3 1/4 dia
4 3/8 dia
3 3/8
3 1/8
5/16 dia
1/2 dia
3 3/4
1 dia
1 1/2 dia
2 dia
3/8 dia
7/8
5/16
2 3/8
4 dia
3/8 dia
5 1/2
4 5/8
5 1/2
1 1/4
7/8
1/4
1/8
1/16
1 1/2
1 5/8
2
1 1/4
1
5/8
5/16
11/16
3/4
1/2
3/8
1/4
1/16
1/8
J
K
L
M
N
P
Q
R
1
2
3
4
5
6

LOCOMOTIVE VALVE ROD GUIDE

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Main Casting . . .	Cast Iron	2	1841
2	Bushes	Gun Metal	4	1842
3	Oil-box Lid	Brass	2	1843
4	Hinge Pin for Lid . . .	Wrought Iron	2	$\frac{5}{16}$″ × $3\frac{3}{4}$″
5	Oil Tubes	,,	4	$\frac{1}{4}$″ ins. dia. $2\frac{3}{8}$″ long $\frac{3}{8}$″ outs.
6	Hex. Hd. Set Screws . .	Mild Steel	4	$\frac{1}{2}$″ × $1\frac{3}{16}$″

Details of the Guide for a Locomotive Valve Rod are given on this plate. The guide consists of a main casting (**1**), lined with gun metal bushes (**2**), the bushes being fixed to the main casting by means of the set screws (**6**). When the bushes are in position with their flanges bearing against the ends of the main casting, there is a gap of $\frac{1}{8}$″ between their flangeless ends.

The bearing surface of the guide is lubricated by the syphon method from the oil-box, formed in the upper part of the main casting. The oil tubes (**5**) are made a tight fit in the holes of the main casting, and, when in position, their lower ends project about $\frac{3}{16}$″ into the holes in the bushes. The guide is bolted to a steel casting, which forms a "stay" for the side frames of the locomotive.

Fig. 1 is a conventional longitudinal section, taken nominally on line (JK), but showing the ribs (L) and (M) in outside view. These ribs are $\frac{3}{4}$″ thick, and are actually on the centre line (JK).

The left-hand half of Fig. 2 is a section on the stepped line (NP), the right-hand half being a section on the line (QR)

Example 36.—Make a drawing (full size) showing all the parts in their proper working positions, giving the following views:—

(1) A sectional elevation corresponding to Fig. 1.

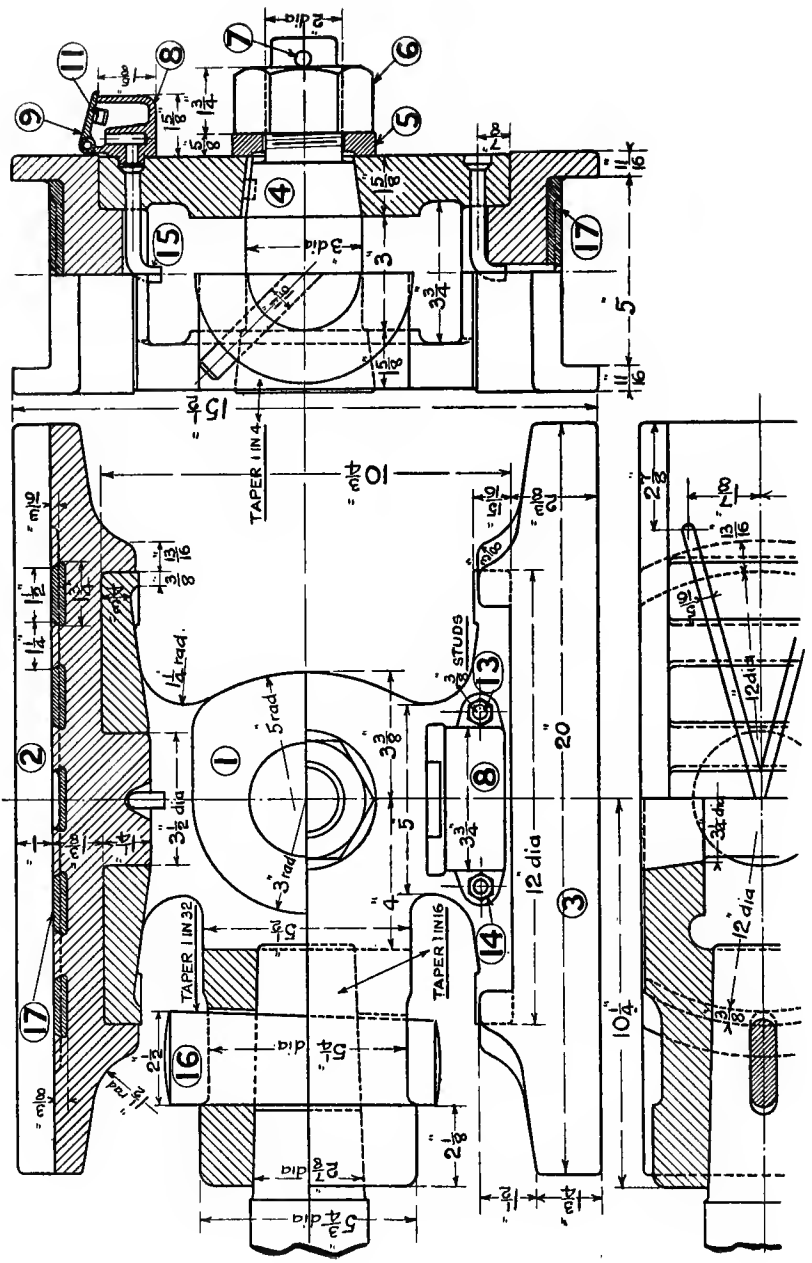
(2) A sectional elevation corresponding to Fig. 2.
(3) A half plan with the oil-box lid removed.

EXAMPLE 37.—Design a similar guide for valve rods $2\frac{1}{2}''$ diameter, working as closely as possible to the following dimensions:—

Outside diameter of bush, $3\frac{1}{8}''$. Length through each bush, $3\frac{3}{4}''$.
Thickness of bush flange, $\frac{5}{16}''$ Diameter of bush flange, $3\frac{3}{4}''$.
Gap between bushes, $\frac{1}{16}''$.
Outside diameter of main casting body, $4\frac{1}{8}''$.
Circular flange on end of body, $4\frac{3}{4}''$ diameter $\frac{3}{4}''$ thick.
Square flange on end of body, $\frac{7}{8}''$ thick. To be as small as possible, consistent with sufficient clearance allowance for bolt heads. (Bolts to be $\frac{3}{4}''$ diameter.)

EXAMPLE 38.—Trace the drawing made to Example 36.

PLATE No. 22


TAPER 1 IN 4
TAPER 1 IN 32
TAPER 1 IN 16
3 STUDS
12" dia
3" dia
5" dia
5 rad.
3" rad.
1/4 rad.
1/8 rad.

LOCOMOTIVE CROSS-HEAD (TWO BARS)

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Cross-head Body	Cast Steel	2	1871
2	,, Slide (upper)	Cast Iron	2	1872
3	,, ,, (lower)	,,	2	1872
4	Gudgeon Pin	Oil Hdnd. Steel	2	—
5	Washer for Pin	Mild Steel		$\frac{5}{8}$″ thick 4″ dia.
6	Hex. Nut for Pin ($1\frac{3}{4}$″ thick)	,,	2	2″
7	Split Pin	,,	2	$\frac{3}{8}$″ × $3\frac{1}{2}$″
8	Oil-box	Brass	2	1873
9	,, Cover	,,	4	1874

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
10	Oil-box Cover Hinge Pin	Brass	4	$\frac{3}{16}$″ dia. $4\frac{1}{4}$″ long
11	,, ,, Spring	Phosphor Bronze	4	$\frac{3}{8}$″ × $\frac{1}{16}$″ × $4\frac{1}{2}$″
12	,, ,, ,, Rivets	Copper	12	$\frac{1}{16}$ × $\frac{7}{16}$″
13	Studs (screwed $\frac{5}{8}$″ at each end)	Mild Steel	8	$\frac{5}{8}$″ × $1\frac{1}{2}$″
14	Hex. Nuts	,,	8	$\frac{5}{8}$″ standard
15	Oil Pipes ($\frac{5}{16}$″ bore)	Wro't Iron	4	$3\frac{1}{2}$″ long
16	Cotter	Steel	2	$2\frac{1}{2}$″ × $\frac{11}{16}$″ × $7\frac{1}{2}$″
17	White Metal	—	—	—
18	Feather for Gudgeon Pin	Mild Steel	2	$\frac{5}{16}$″ square × $\frac{1}{2}$″ long

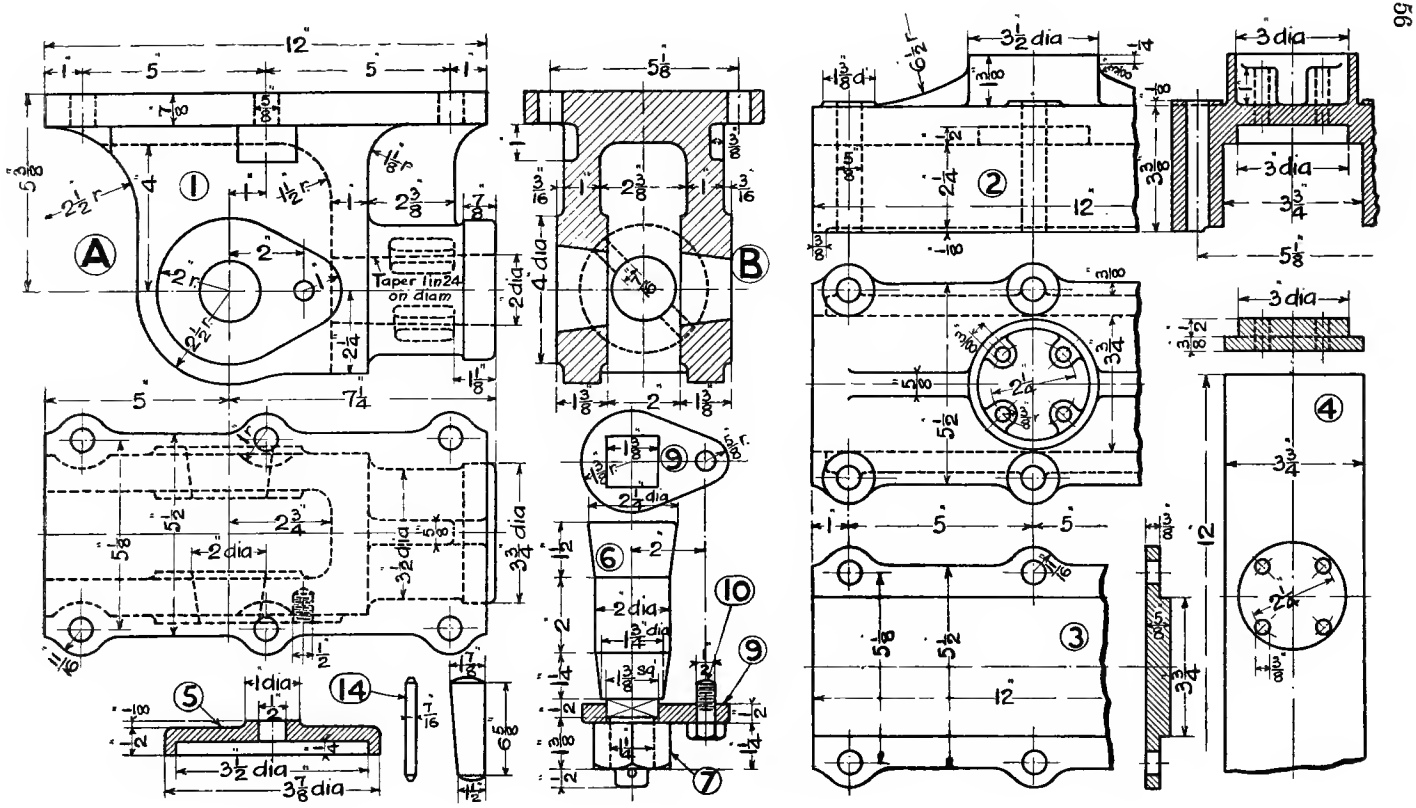
The illustration shows an incomplete general arrangement of a Locomotive Cross-head suitable for working between two slide bars.

The cross-head consists of a central steel casting (**1**) and an upper and lower slide, the slides being of cast iron. The sliding surfaces are lined with white metal, that of the lower slide being lubricated from the lower oil-box. The upper slide is lubricated from an external source. The upper oil-box provides lubrication for the connecting rod end bearing on the gudgeon pin. The gudgeon pin is prevented from turning by means of the feather (**18**).

Example 39.—Make separate detail working drawings of each of the following items: **1**, **2**, and **4**.

Example 40.—Make a complete working drawing of the oil-box, items **8** to **12** inclusive.
Use the following scales: Items **1** and **2**, 6″ = 1′. Other items to be drawn full size.

PLATE No. 23


A
B
Taper 1 in 24 on diam
4 dia
2 dia
3½ dia
3⅞ dia
1 dia
3 dia
3¾ dia
5⅛
7¼
12
5
2
4
2½ r
6½ r

LOCOMOTIVE CROSS-HEAD

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Cross-head Body . . .	Cast Steel	2	1257
2	,, Cap . . .	Cast Iron	2	1258
3	,, Liner (lower) .	Gun Metal	2	1259
4	,, ,, (upper) .	,,	2	1260
5	Lid for Oil-box . . .	Brass	2	1261
6	Gudgeon Pin	Mild Steel	2	
7	Hexagonal Nut . . .	,,	2	$1\frac{1}{4}$″ standard
8	Split Pin	Mild Steel	2	$\frac{1}{4}$″ × 2″
9	Locking Plate . . .	,,	2	4″ × $2\frac{3}{4}$″ × $\frac{1}{8}$″
10	Hex. Head Set Bolt . .	,,	2	$\frac{1}{2}$″ × 1″
11	,, ,, Bolts . . .	,,	12	$\frac{5}{8}$″ × $5\frac{1}{2}$″
12	,, Nuts . . .	,,	12	$\frac{5}{8}$″ standard
13	Split Pins	,,	12	$\frac{1}{8}$″ × $1\frac{1}{4}$″
14	Cotter	Cotter Steel	2	$1\frac{7}{8}$″ × $\frac{7}{16}$″ × 7″

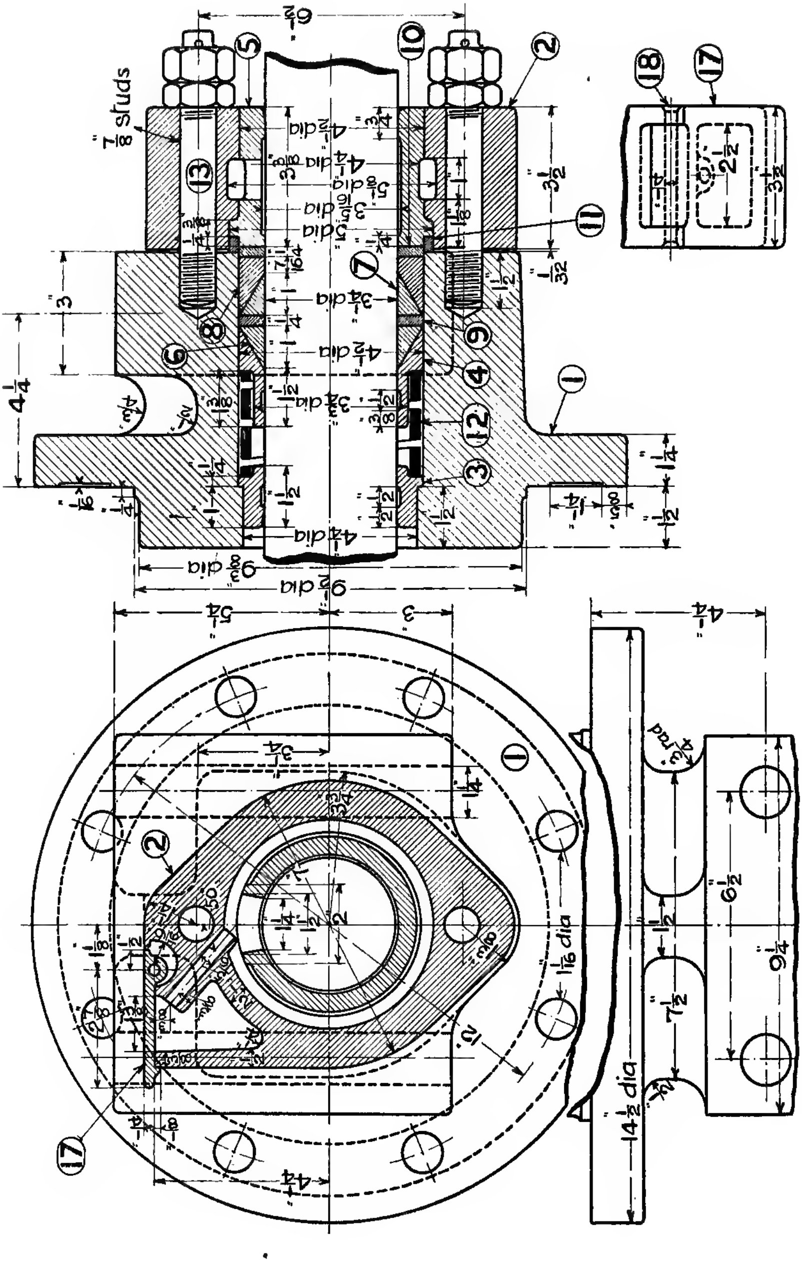
Complete details of a Locomotive Cross-head are given on this plate. This type of cross-head is used for single slide bar engines.

The piston rod end fits in the tapered socket of the cross-head body (**1**), and is fixed thereto by means of the tapered cotter (**14**). The gudgeon pin (**6**) is also fitted into the cross-head body, the central parallel portion of the pin forming a bearing for the connecting rod end. The gudgeon pin is prevented from turning under the action of the connecting rod, by means of the locking plate (**9**). Lubrication for the slide bar is obtained by syphoning the oil from the box in the cross-head cap (**2**).

Example 41.—Make a drawing showing all the parts assembled together in their working positions.

Show two elevations and a plan to a scale of 6″ = 1′. Make the side elevation an outside view corresponding to Fig. A, and the end elevation a sectional view corresponding to Fig. B. Make the upper half of the plan an outside view, with the oil-box cap removed, the lower half of the plan being sectional, the section being taken along the horizontal centre line of the gudgeon pin and piston rod socket.

PLATE No. 24



7/8" studs
4 1/2" dia
4 1/4" dia
3 3/4" dia
9 3/8" dia
9 1/2" dia
1 1/16" dia
14 1/2" dia

STUFFING BOX WITH METALLIC PACKING

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Cylinder Cover	Cast Iron	2	172
2	Gland Box	,,	2	173
3	Neck Bush	Gun Metal	2	174
4	Forcing Bush	,,	2	175
5	Gland Box Bush	,,	2	176
6	Packing Bushes (split)	White Metal	2	—
7	,, ,,		2	—
8	,, ,,	,,	2	—
9	,, Rings	,,	2	—
10	,, ,,		2	—

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
11	Packing Rings	White Metal	2	$\frac{3}{32}$″ wide
12	Helical Spring, 4½″ long (uncompressed)	Spring Steel	2	$\frac{5}{64}$″ × $\frac{5}{16}$″ rectangular section
13	Studs (screwed 1½″ and 1¾″)	Mild Steel	4	$\frac{3}{8}$″ × 7″
14	Hex. Nuts	,,	4	$\frac{3}{8}$″
15	,, Lock Nuts	,,	4	$\frac{3}{8}$″
16	Split Pins for Studs	,,	4	$\frac{1}{16}$″ × 1¼″
17	Oil-box Lids	Brass	2	177
18	Hinge Pins for Lids	Brass (wire)	2	¼″ dia. 3¾″ long

The illustration facing this page shows a Cover for a Locomotive Cylinder. The stuffing box formed in the cover is arranged to accommodate metallic packing bushes and rings (items **6** to **11**). The bushes, being made conical in shape and in separate halves, the helical spring (**12**) forces the packing on to the rod, thus keeping the cover steam-tight. Lubrication is by syphon from the oil-box formed in the gland-box (**2**). The cylinder cover carries the end of the slide bar on which the cross-head slides, and the two 1¼″ diameter holes shown are for the bolts fixing the slide bar to the cover.

Example 42.—Make separate detail working drawings of each of the following items: **1**, **2**, **3**, **4**, and **5**.

Item **1** to be drawn half full size, and the remaining items full size. Items **17** and **18** to be incorporated with item **2**.

Example 43.—Design a stuffing box with metallic packing suitable for a piston rod 1⅝″ diameter, working as closely as possible to the following dimensions:—

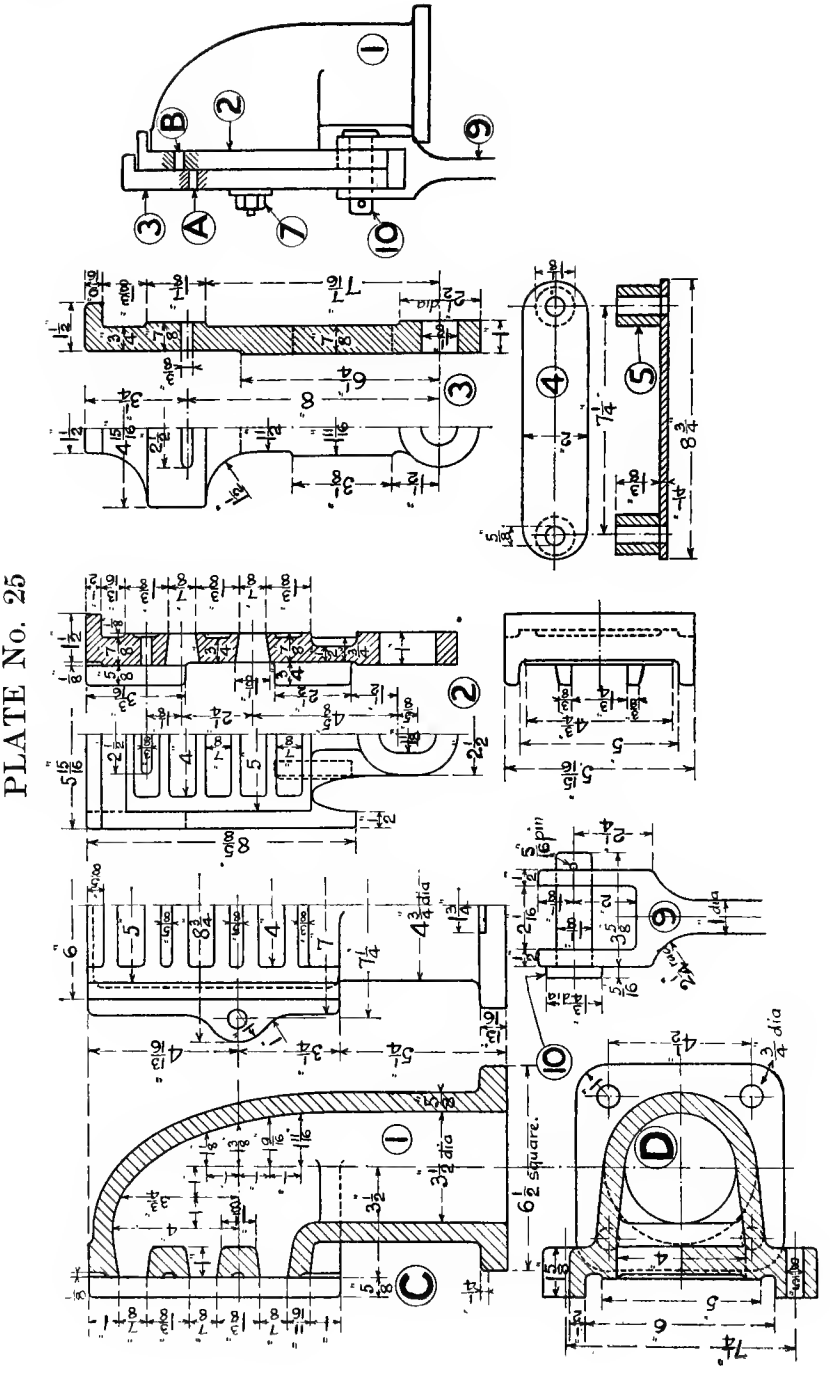
Diameter of stuffing box, 2⅝″. Diameter of neck, 2⅜″. Length of box between neck and gland-box, 5⅛″. Length through gland-box, 2″. Helical spring, $\frac{5}{8}$″ × $\frac{3}{16}$″ rectangular section. Inside diameter, 1$\frac{5}{16}$″. Working length, 2⅜″. Fully compressed, 2⅛″. Uncompressed, 3⅜″. Length of white-metalled surface, 2½″. Use ¾″ studs for fixing the gland-box.

Only that portion of the cylinder cover directly concerned with the stuffing box need be shown.

Scale, Full Size.

Example 44.—Trace the drawing made in Example 42 or 43.

PLATE No. 25



STEAM REGULATOR FOR LOCOMOTIVE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Regulator Head . . .	Cast Iron	1	556
2	Main Valve	Gun Metal	1	557
3	Auxiliary Valve . .	Cast Iron	1	558
4	Retaining Plate . .	Wro't Iron	1	$8\frac{3}{4}'' \times 2'' \times \frac{1}{4}''$
5	Distance Ferrules . .	,,	2	$1\frac{1}{8}''$ dia. $\times 1\frac{3}{8}''$ long
6	Hex. Hd. Bolts . .	Mild Steel	2	$\frac{5}{8}'' \times 4\frac{1}{4}''$
7	,, Nuts	,,	2	$\frac{5}{8}''$
8	Split Pins . . .	,,	2	$\frac{5}{32}'' \times 1\frac{1}{2}''$
9	Actuating Lever . .	Wro't Iron	1	—
10	Pin for Lever . . .	Mild Steel	1	$1\frac{1}{4}'' \times 3\frac{5}{8}''$
11	Split Pin for Lever . .	,,	1	$\frac{5}{32}'' \times 2''$

Details of a Steam Regulator for a Locomotive are given on the accompanying plate.

The regulator, which is also the starting valve, is situated high up in the steam dome on the boiler, and its action is controlled by means of an arrangement of rods and levers from the foot-plate of the locomotive.

The action of the regulator is as follows: Attached to the lower end of the actuating link (9) is a lever. This lever is fixed to a rod which passes along the inside of the boiler, and through a stuffing box fixed to the back plate of the boiler. On the end of this rod a lever with a handle is fixed, by the movement of which the regulator valve is controlled. The head of the regulator (1) is fixed to a steam pipe leading directly to the steam chests of the cylinders.

Because of the large surface of the main valve (2), and the consequent pressure upon it, it would be impossible for the driver to give the valve the necessary movement unless some special provision was made to relieve the valve of this pressure. The use of the auxiliary valve obviates this difficulty.

When the actuating link (9) is moved upwards, the auxiliary valve (3), which has a comparatively small surface area on which the unbalanced steam pressure acts, also moves upwards. The main valve (2) remains stationary until the port (A) in the auxiliary valve (3) comes opposite to the port (B) in the main valve (2). Steam is then admitted through these ports from the boiler to the regulator head, and the pressure on the main valve largely balanced. The main valve is then easily moved.

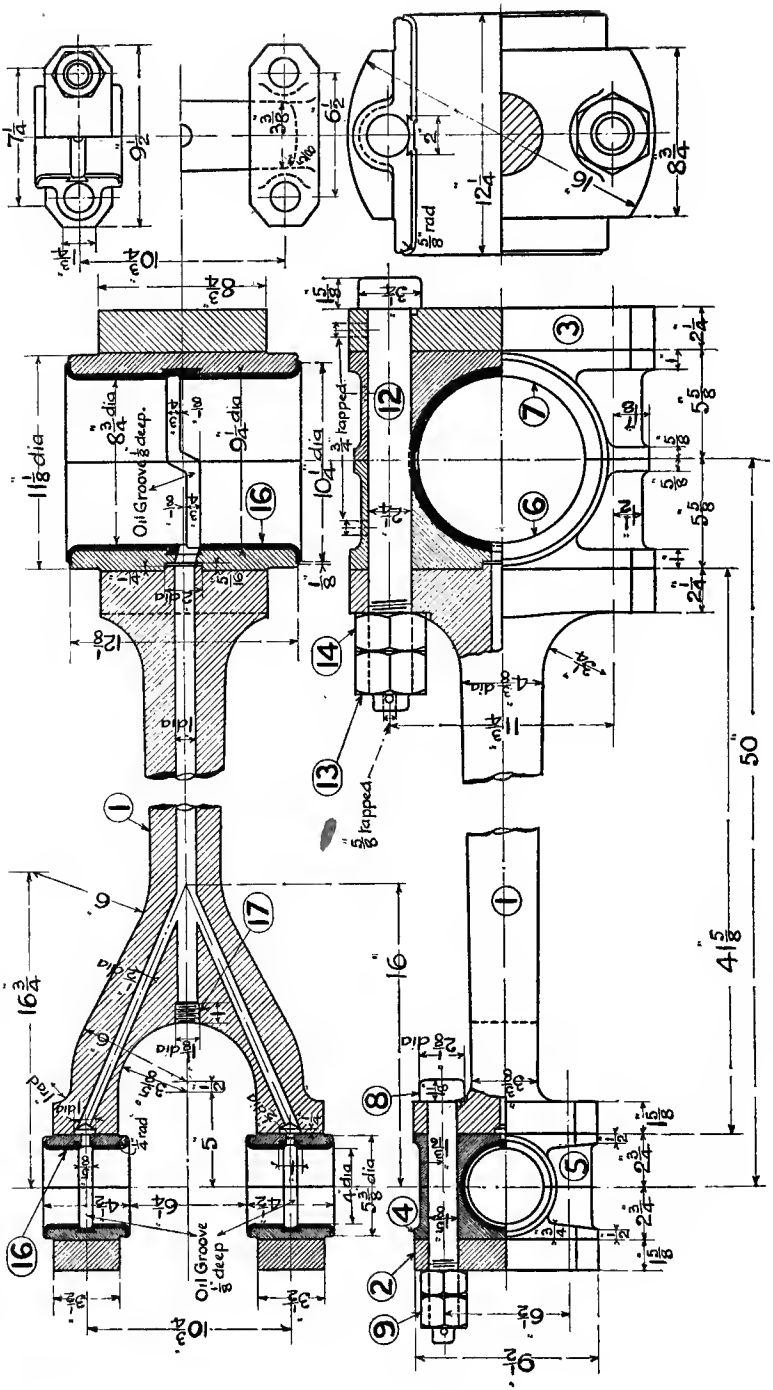
Example 45.—Make a drawing showing all the parts assembled together in their correct working positions. Give the following views to a scale of $6'' = 1'$:—

(*a*) A sectional elevation corresponding to view C.

(*b*) A sectional plan corresponding to view D.

(*c*) An end elevation, the left-hand half of which is to show the auxiliary valve and the retaining plate removed.

PLATE No. 26


Oil Groove
Oil Groove
50
41 5/8
16 3/4
16
10 3/4
8 3/4
11 1/8 dia
10 1/4 dia
9 1/4 dia
8 3/4 dia
5 1/8 dia
4 dia
2 3/8 dia
2 dia
1 dia
5/8 rad
5/8 tapped
3/4 tapped
1 1/8 tapped
1 1/4 tapped
1 1/2 tapped
1 3/4 tapped
2 tapped
2 1/4 tapped
2 1/2 tapped
3 tapped
3 1/4 tapped
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49 tapped
49 1/2 tapped
50 tapped

CONNECTING ROD FOR HIGH-SPEED VERTICAL STEAM ENGINE

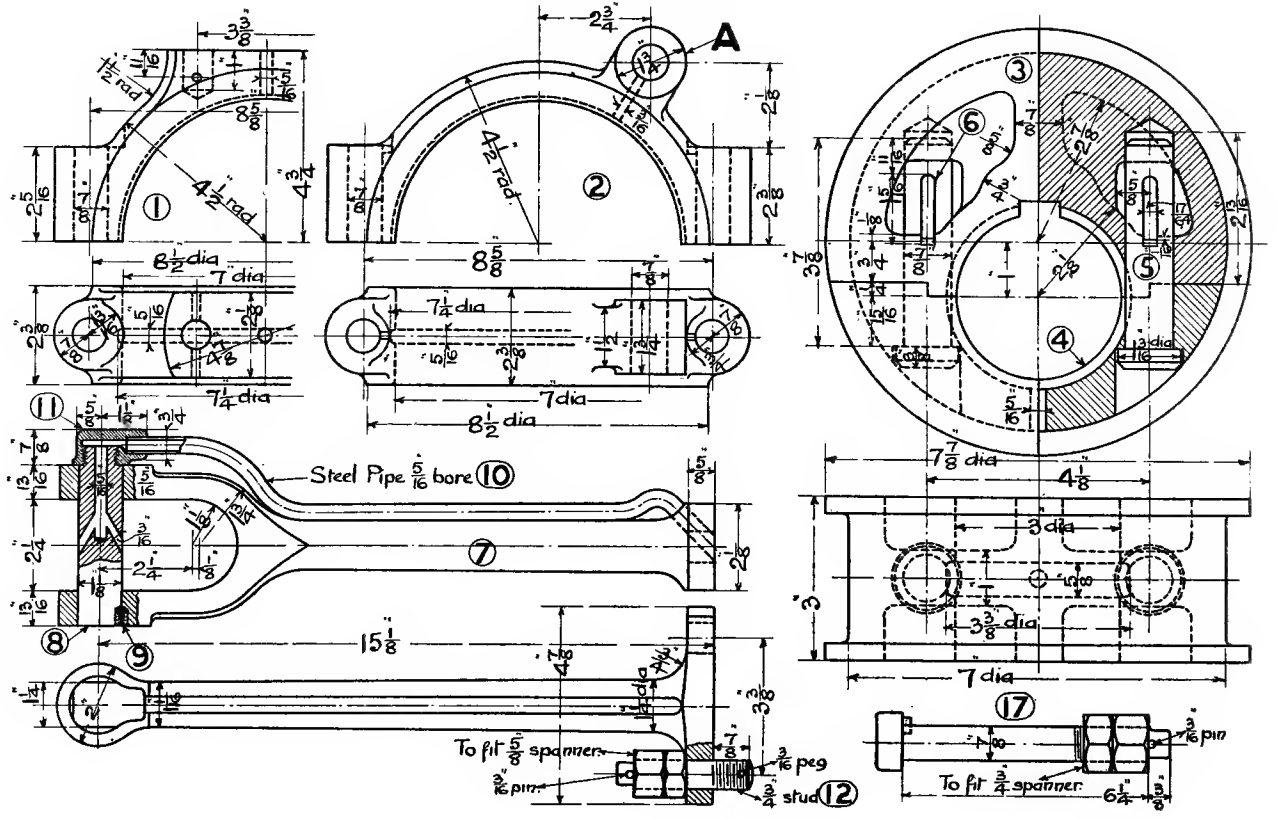
Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Connecting Rod	Mild Steel	1	Forging
2	,, ,, Cap, Small End	,,	2	—
3	,, ,, ,, Large End	,,	1	—
4	Small End Brasses, Upper Half	Gun Metal	2	201
5	,, ,, Lower Half	,,	2	201
6	Large End Brasses, Upper Half	,,	1	202
7	,, ,, Lower Half	,,	1	202
8	Rd. Hd. Bolts for Small End	Mild Steel	4	$1\frac{5}{8}''$ × $12\frac{3}{4}''$ screwed $3\frac{3}{4}''$
9	Hex. Nuts	,,	4	$1\frac{5}{8}''$
10	,, Lock Nuts	,,	4	$1\frac{5}{8}''$
11	Split Pins	,,	4	$\frac{1}{4}''$ × $2\frac{3}{4}''$
12	Rd. Hd. Bolts for Large End	,,	2	$2\frac{1}{4}''$ × $21''$ screwed $5\frac{1}{4}''$
13	Hex. Nuts	,,	2	$2\frac{1}{4}''$
14	,, Lock Nuts	,,	2	$2\frac{1}{4}''$
15	Split Pins	,,	2	$\frac{5}{16}''$ × $3\frac{3}{4}''$
16	Necessary White Metal	—	—	—
17	Plug	Mild Steel	1	$1\frac{1}{8}''$ dia. 1″ long

Example 46.—Separate detail working drawings are to be made of each of the following items: **1**, **2**, **3**, **4**, **5**, **6**, **7**, **8**, and **12**. In making the drawing of the rod (item **1**) the upper halves of the elevation and plan are to be shown as outside views, and the curves of interpenetration carefully projected.

In making the drawings of the bolts (items **8** and **12**) the nuts and split pins are to be included, shown in position on the bolts. The latter may be shown broken to economise space. The pegs in the necks of the $2\frac{1}{4}''$ bolts are $\frac{5}{16}''$ diameter × $\frac{5}{8}''$ long, and those in the $1\frac{5}{8}''$ bolts are $\frac{1}{4}''$ diameter × $\frac{1}{2}''$ long.

Note.—The $\frac{3}{4}''$ tapped holes in items **3**, **6**, and **7**, and the $\frac{5}{8}''$ tapped hole in the end of item **12**, are to facilitate the handling of these parts when assembling or dismantling the engine.

PLATE No. 27


A
Steel Pipe 5/16 bore
To fit 5/8 spanner
To fit 3/4 spanner
3/16 peg
3/16 pin
3/4 stud

ECCENTRICS FOR VERTICAL HIGH-SPEED STEAM ENGINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Eccentric Strap, Upper Half	Cast Iron	1	1211
2	,, ,, Lower Half	,,	1	1212
3	,, Sheave (large segment)	,,	1	1213
4	Eccentric Sheave (small segment)	,,	1	1214
5	Cottered Bolts	Mild Steel	2	$\frac{7}{8}'' \times 3\frac{7}{8}''$
6	Cotters	Steel	2	—
7	Eccentric Rod	Mild Steel	1	—
8	Pin for Forked End	Case Hdnd. Steel	1	—
9	Grub Screw	Mild Steel	1	$\frac{1}{4}'' \times \frac{1}{16}''$

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
10	Oil Pipe (weldless tube)	Steel	1	$\frac{5}{16}''$ bore
11	,, Connector	Brass	1	1215
12	Studs (screwed $\frac{3}{8}''$ and $1\frac{1}{2}''$)	Mild Steel	2	$\frac{3}{4}'' \times 3\frac{1}{4}''$
13	Hex. Nuts (tapped $\frac{3}{8}''$)	,,	2	To fit $\frac{5}{8}''$ spanner
14	,, Lock Nuts (tapped $\frac{3}{8}''$)	,,	2	To fit $\frac{5}{8}''$ spanner
15	Split Pins	,,	2	$\frac{3}{16}'' \times 1\frac{1}{2}''$
16	Peg	,,	2	$\frac{1}{16}'' \times 2\frac{1}{2}''$
17	Cheese Hd. Bolts	,,	2	$\frac{1}{8}'' \times 6\frac{3}{8}''$
18	Hex. Nuts (tapped $\frac{7}{8}''$)	,,	2	To fit $\frac{3}{4}''$ spanner
19	,, Lock Nuts (tapped $\frac{7}{8}''$)	,,	2	To fit $\frac{3}{4}''$ spanner
20	Split Pins	,,	2	$\frac{3}{16}'' \times 1\frac{1}{2}''$

Various views are given on this plate of the details of an Eccentric and Rod for a High-speed Vertical Steam Engine.

Forced lubrication is used in these engines. The bearing working on the eccentric rod pin (8) is lubricated by oil carried through the pipe (10) and reaching the bearing surface *via* the holes in the pin.

The lug (A) on the lower half strap is fitted with a crank pin (not shown) from which is driven the oil pump providing the forced lubrication.

The two parts of the sheave (3 and 4) are held together by means of cottered bolts, the cotters being $1\frac{3}{16}'' \times \frac{17}{64}''$ mean section and 2″ long. The cotters are tapered in the width but not in the thickness, the taper being 1 in 48 and on one side only.

To effect a small reduction in over-all size it should be noted that special nuts are used for the studs and bolts.

The sheave is fixed to the shaft by means of a key of British standard section.

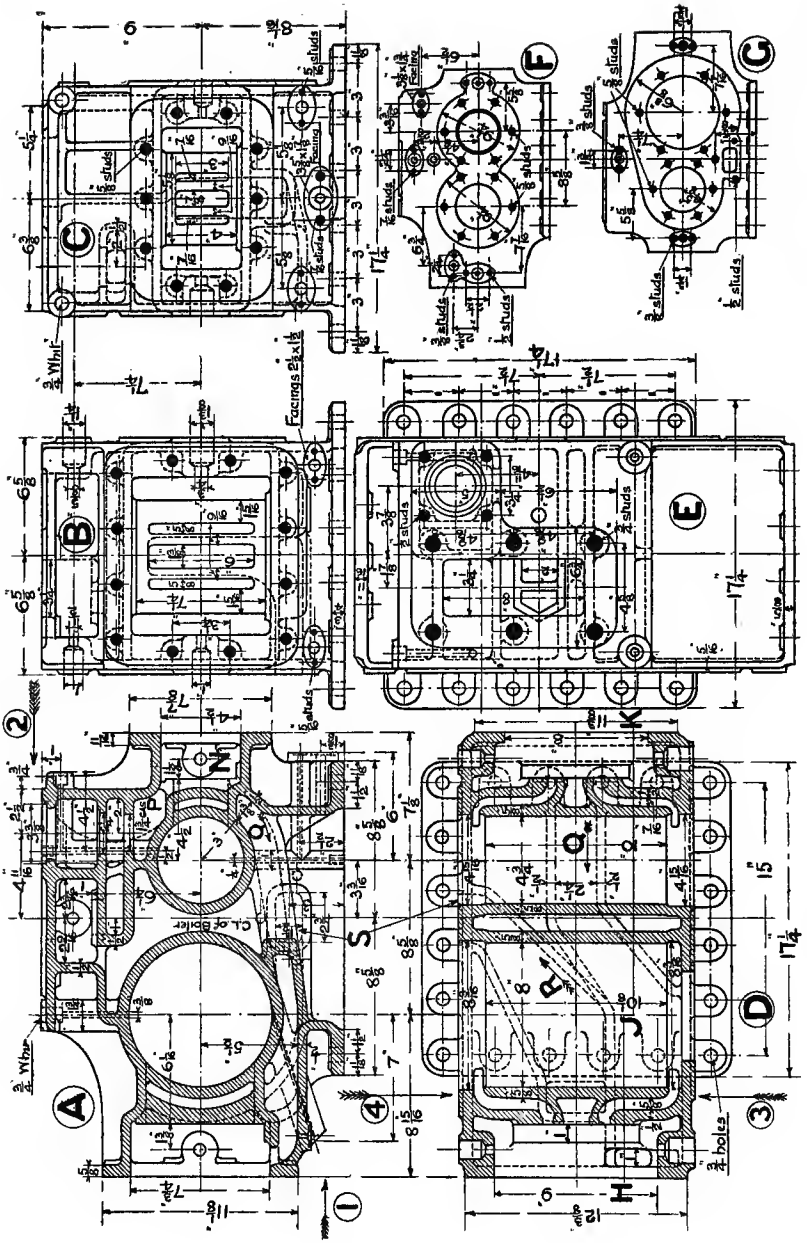
Example 47.—Make a full size drawing showing all the parts assembled together in their working positions.

Show two elevations and a plan, making sectional or outside views according to which indicate the shape and size of the various details most clearly.

Insert all dimensions.

Example 48.—Trace the drawing made to Example 47.

PLATE No. 28


A
B
C
D
E
F
G
H
J
K
L
N
P
Q
R
S
Facings
studs
holes
Wire
Center of Boiler

CYLINDERS FOR TRACTION ENGINE

The Cylinders for a Compound Steam Tractor are shown on this plate, the views given being as follows:—

"A" is a sectional elevation, the section being taken on the line HJK.
B is an end elevation taken looking in the direction indicated by arrow (1).
C is an end elevation taken looking in the direction indicated by arrow (2).
D is a sectional plan, the section being taken on the horizontal centre line of the cylinders.
E is a plan of the top.
F is a front elevation taken looking in the direction indicated by arrow (3).
G is a back elevation taken looking in the direction indicated by arrow (4)

The cylinder casting is fixed to a pressed steel mounting, which is riveted to the boiler shell, and steam passes directly from the boiler through a hole in the mounting into the space between and around the cylinders. The cylinders are thus jacketed with steam at boiler pressure, as is also the passage from the high to the low pressure cylinder.

A starting valve, a governor with throttle valve, and a safety valve are all fitted on the top of the cylinder.

Steam is admitted by the starting valve to the passage marked P (view A) past the governor throttle valve, and thence to the high pressure valve chest N. The exhaust steam from the HP cylinder passes to the LP cylinder along the passage marked Q.

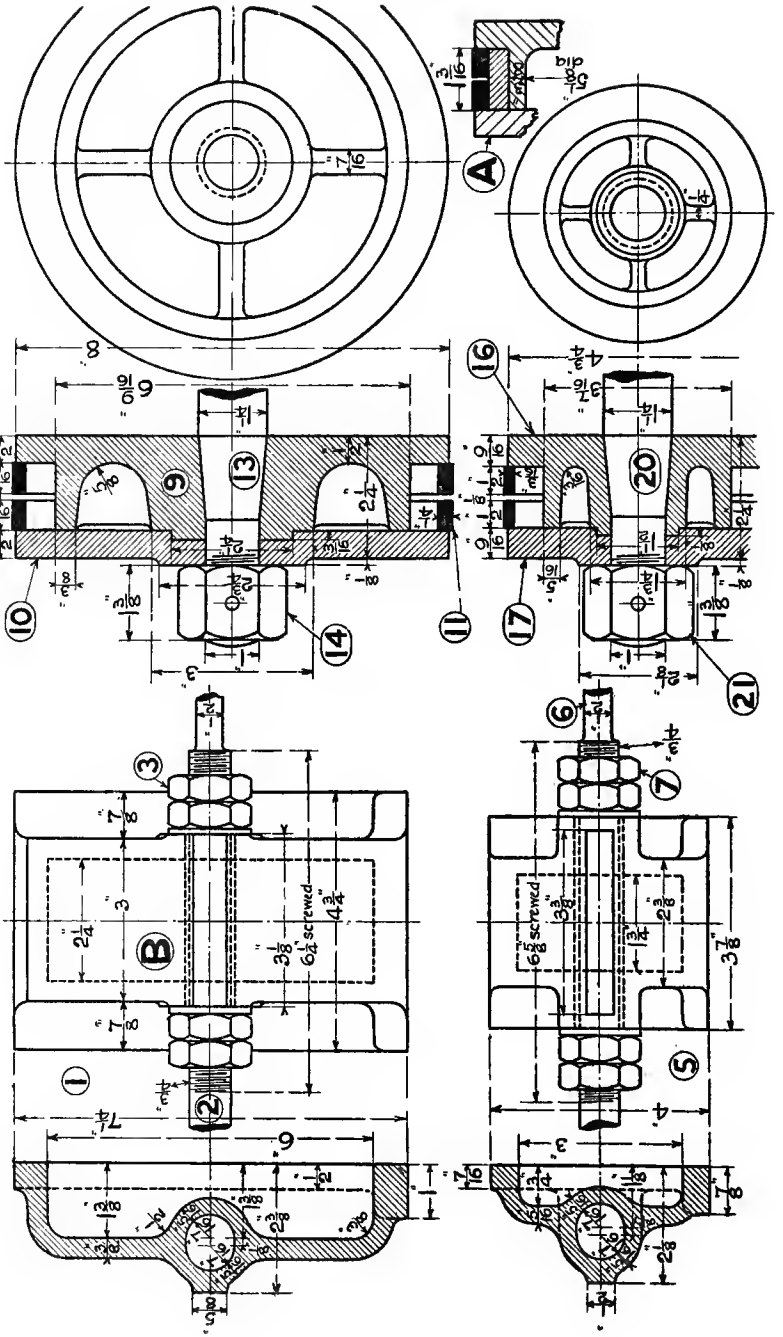
The final exhaust from the LP cylinder is along the passage R (see view D), and through the opening S.

A by-pass valve is also fitted to admit high pressure steam direct to the low pressure cylinder to give temporary increases of power when starting the engine with a heavy load, or when negotiating difficult ground.

The brake horse-power developed by the engine is 20, with a steam pressure (boiler pressure) of 200 lbs. □″. The stroke is 9″.

EXAMPLE 49.—Make a drawing (scale, 6″ = 1′) showing a sectional view corresponding to view D, but showing the pistons, slide valves, and covers, etc., in position. Above this view project an outside view end elevation corresponding to view F. Details of the pistons, slide valves, covers, etc., are to be obtained from Plates Nos. 29, 30, and 31.

PLATE No. 29



SLIDE VALVES AND PISTONS FOR TRACTION ENGINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Low Pressure Slide Valve	Cast Iron	1	1816
2	,, Valve Spindle	Mild Steel	1	—
3	Hex. Lock Nuts, $\frac{1}{2}$″ thick	Brass	4	$\frac{3}{8}$″
4	Washers, $\frac{1}{8}$″ thick	,,	2	$\frac{3}{4}$″
5	High Pressure Slide Valve	Phosphor Bronze	1	1817
6	,, Valve Spindle	Mild Steel	1	—
7	Hex. Lock Nuts, $\frac{1}{2}$″ thick	Brass	4	$\frac{3}{8}$″
8	Washers, $\frac{1}{8}$″ thick	,,	2	$\frac{3}{4}$″
9	Low Pressure Piston Body	Cast Iron	1	1819
10	,, ,, Cover Plate	,,	1	1820
11	,, ,, Rings	,,	2	1821
12	,, ,, Springs	Spring Steel	1	—
13	Low Pressure Piston Rod	Mild Steel	1	—
14	,, ,, ,, Nut (Hex.)	,,	1	—
15	Taper Pin for Nut	—	1	$\frac{1}{4}$″ to $\frac{5}{16}$″ dia. 2″ long
16	High Pressure Piston Body	Cast Iron	1	1822
17	,, ,, Cover Plate	,,	1	1823
18	,, ,, Rings	,,	2	1824
19	,, Springs	Spring Steel	1	—
20	,, ,, Rod	Mild Steel	1	—
21	,, ,, ,, Nut (Hex.)	,,	1	—
22	Taper Pin for Nut	—	1	$\frac{1}{4}$″ to $\frac{5}{16}$″ dia. 2″ long

The Slide Valves and Pistons shown on this plate are to be incorporated on the arrangement drawing called for on page 67. Both valves and pistons are of a pattern which is almost a standard with many manufacturers of steam engines of small power.

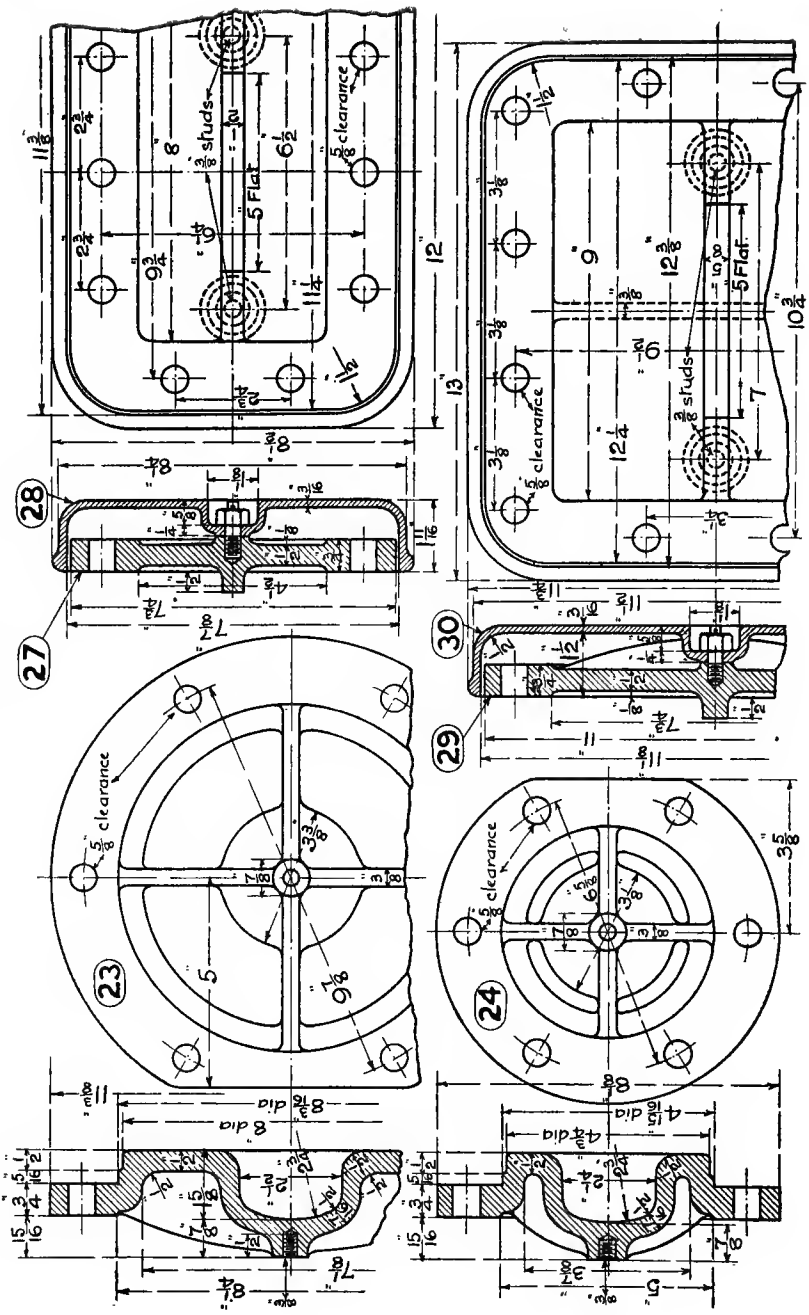
The taper of the rods in the pistons is 1 in 6 on the diameter.

Example 50.—Make a working drawing, scale full size, of a slide valve, similar in shape to item **1**, but to the following dimensions: Over-all size, $6\frac{1}{2}$″ × $4\frac{1}{4}$″, instead of $7\frac{1}{4}$″ × $4\frac{3}{4}$″. Depth inside, $1\frac{1}{4}$″, instead of $1\frac{3}{8}$″. Opening, $5\frac{1}{4}$″ × $1\frac{3}{4}$″, instead of 6″ × $2\frac{1}{4}$″. Hole for spindle, same size as in illustration, but to be $\frac{1}{8}$″ nearer to the face of the valve. Total height to top of facing, $2\frac{1}{4}$″, instead of $2\frac{3}{8}$″.

Show the valve spindle, with nuts and washers complete as in the plate, and, in addition to the two views given, add a plan under view **B** in projection with view **B**.

Example 51.—Make a working drawing of a piston similar to the one shown by items **9** to **15**, but to the following dimensions: Diameter, 7″, instead of 8″. Section of piston rings, $\frac{9}{16}$″ × $\frac{1}{4}$″. Show a steel spring-ring, as in the auxiliary view **A**, the section of the ring being $1\frac{1}{8}$″ × $\frac{1}{4}$″. Other details may be as shown on the plate.

PLATE No. 30



Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
23	Low Pressure Cylinder Cover	Cast Iron	1	1825
24	High ,, ,, ,,	,,	1	1826
25	Studs (screwed 1″ each end) .	Mild Steel	12	$\frac{5}{8}$″ × 2½″
26	Hex. Nuts	,,	12	$\frac{5}{8}$″
27	High Pressure Steam Chest Cover	Cast Iron	1	1827
28	High Pressure Steam Chest Casing	,,	1	1828

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
29	Low Pressure Steam Chest Cover	Cast Iron	1	1829
30	Low Pressure Steam Chest Casing	,,	1	1830
31	Studs (screwed 1″ each end) .	Mild Steel	22	$\frac{5}{8}$″ × 2½″
32	Hex. Nuts	,,	22	$\frac{5}{8}$″
33	Studs	,,	4	$\frac{3}{8}$″ × 1½″
34	Hex. Nuts . . .	,,	4	$\frac{3}{8}$″
34A	Split Pins	,,	4	$\frac{3}{32}$″ × 1″

Incomplete views of the Cylinder and Steam Chest Covers for the Traction Engine Cylinder shown on Plate No. 28 are given on the plate facing this page. All these details are to be incorporated in the arrangement drawing called for on page 67.

Example 52.—Make a working drawing of a cylinder cover similar to items **23** and **24**, but working to the following dimensions:—

Diameter of spigot, $6\frac{9}{16}$″.

Diameter of flange, $9\frac{3}{4}$″.

Inside diameter of domed centre, $2\frac{3}{8}$″.

To be fixed to cylinder by six $\frac{5}{8}$″ studs, equally spaced on a circle $8\frac{1}{4}$″ diameter. One stud to be completely shown in position with sufficient of the cylinder flange and body to indicate the fastening clearly. The flange to be completely circular, and not cut off on one side as in the illustration. In all other respects the design is to be similar to the ones shown.

Example 53.—Make a working drawing of a steam chest cover with casing similar to items **27** to **30**, but working to the following dimensions:—

Over-all size of cover, $11\frac{3}{4}$″ × 9″.

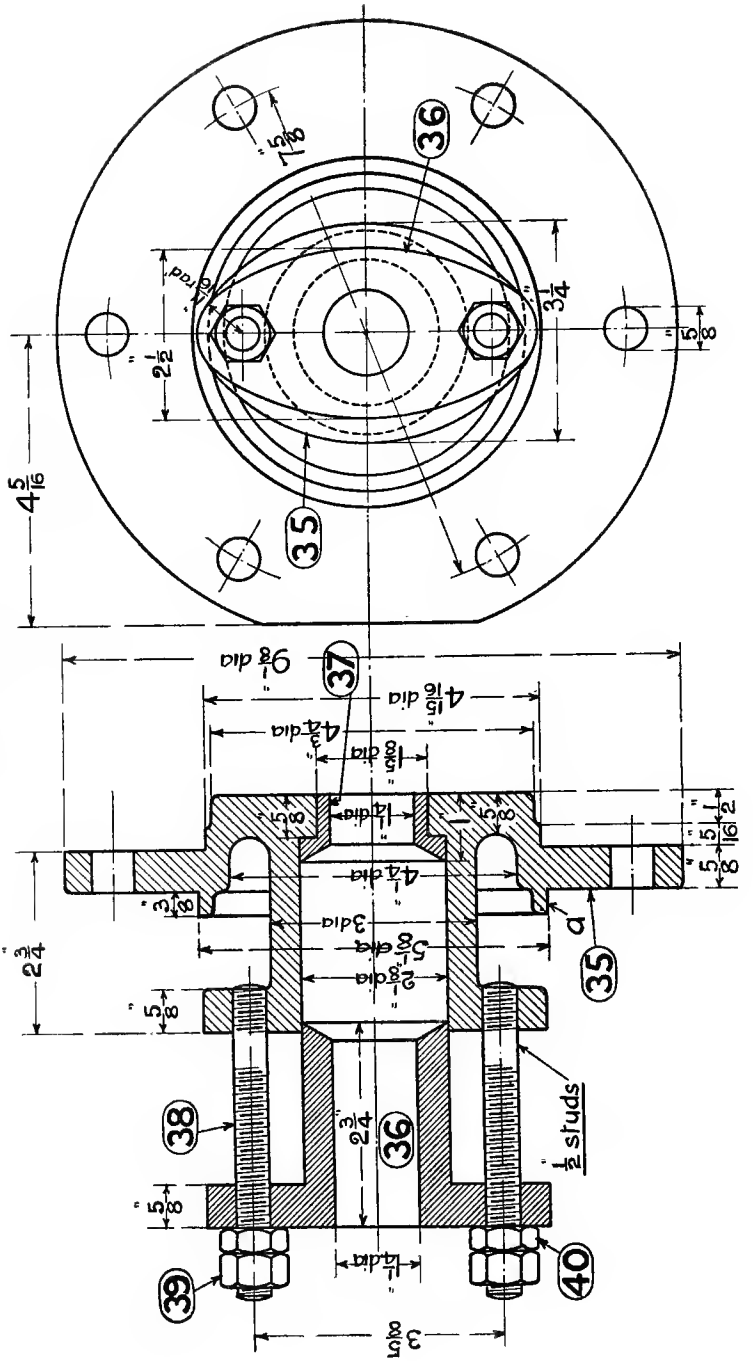
Over-all size of casing, $12\frac{1}{2}$″ × $9\frac{3}{4}$″.

In other respects the design to be exactly as shown, care being taken to arrange the pitch of the studs to suit the new size of cover.

Both examples to be drawn full size.

Example 54.—Trace the drawing made to Example 52 or 53.

PLATE No. 31



COVER AND STUFFING BOX FOR TRACTION ENGINE CYLINDER

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
35	Cover and Stuffing Box	Cast Iron	2	1831
36	Gland	Gun Metal	2	1832
37	Neck Bush	,,	2	1833
38	Studs (screwed $\frac{5}{8}$″ and $3\frac{1}{2}$″)	Mild Steel	4	$\frac{1}{2}$″ × $4\frac{1}{2}$″
39	Hex. Nuts for Studs	,,	4	$\frac{1}{2}$″
40	,, Lock Nuts for Studs	,,	4	$\frac{1}{2}$″
41	Studs for Fixing Cover (screwed 1″ each end)	,,	12	$\frac{5}{8}$″ × $2\frac{1}{4}$″
42	Hex. Nuts	,,	12	$\frac{5}{8}$″

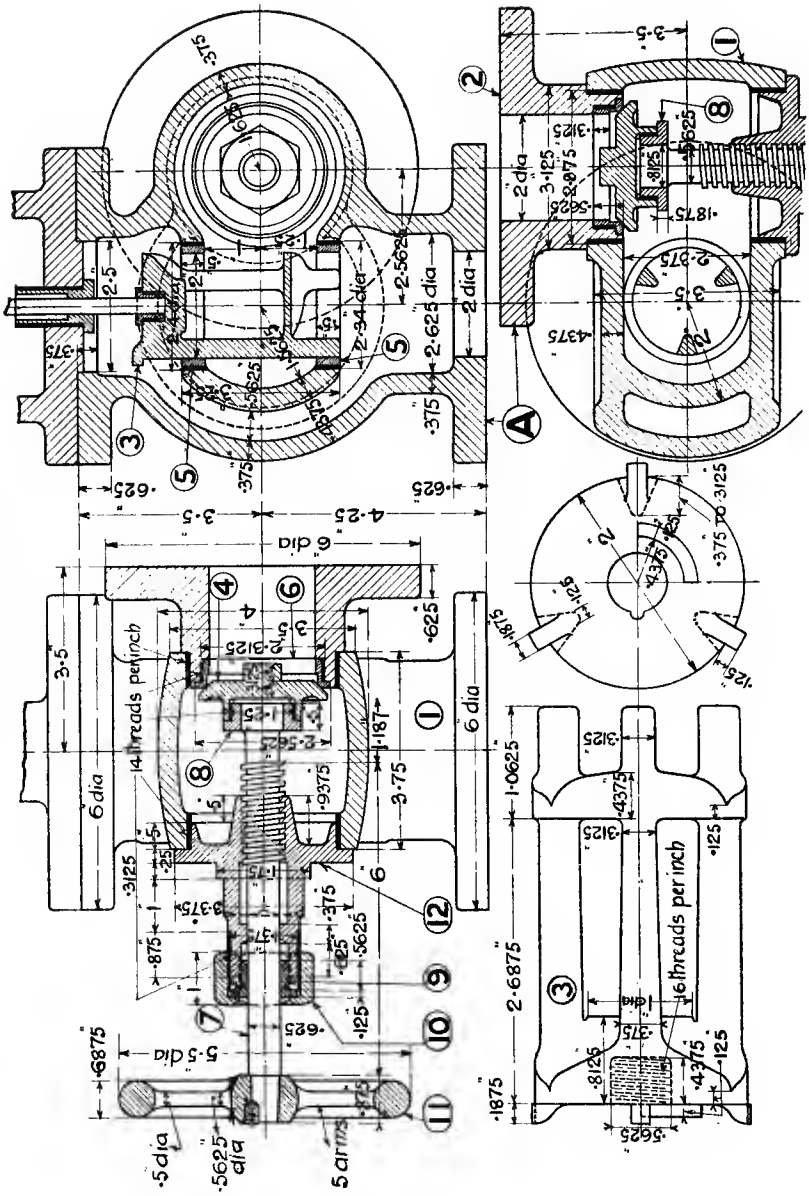
The Cover and Stuffing Box shown on this plate are to be embodied in the general arrangement drawing called for on page 67. It will be noted, on reference to Plate No. 28, that the high and low pressure cylinders are cast together. Their centres being too close together to allow of the flange of the cover being completely circular, a piece is cut away on one side as shown in the end view of the cover on the plate facing this page.

Example 55.—Make a working drawing, full size, of a similar cover and stuffing box, etc., but to the following particulars:—

Diameter of flange, 12″; thickness, $\frac{3}{4}$″. Diameter of spigot, 8″ instead of $4\frac{15}{16}$″. Diameter of piston rod, $1\frac{1}{2}$″. Inside diameter of stuffing box, $2\frac{3}{8}$″; outside diameter, $3\frac{3}{8}$″. Face of cover flange to face of stuffing box, $3\frac{1}{4}$″ instead of $2\frac{3}{4}$″. Length through gland, 3″. Diameter of neck bush, $1\frac{7}{8}$″. Use two $\frac{1}{2}$″ studs for the gland at 4″ centres. Width of gland flange, $2\frac{3}{4}$″. Width of stuffing box flange, $3\frac{5}{8}$″. Diameter of recessed part of cover, $6\frac{3}{4}$″ instead of $4\frac{1}{4}$″. Show eight $\frac{5}{8}$″ clearance holes in the flange of the cover, equally spaced on a circle $10\frac{1}{2}$″ diameter.

Note.—When used for the traction engine the cylinder cover carries the guide for the cross-head, and the outside spigot marked "*a*" is for this purpose. This spigot is not required in the example to be drawn.

PLATE No. 32


6 dia
4·25
3·5
14 threads per inch
5·5 dia
·5 dia
·5625 dia
5 arms
16 threads per inch
2·6875
1·0625
2 dia
2·625 dia
2·5625 dia
2·34 dia
·6875
·1875
·625
·375
·125
·187
·9375
·875
·5625
·4375
·3125
·8125
·1875
·2175
·2·375
·3·125
·4·375
·3·75
·6·25
·1·875
·2·875
·3·375
·4·375
·3·5
·2·5
·4375
·1875
·2·375
·3·125
·2·875
·3·625
·4·125
·3·75 to 3·125
·2·5
·3·5
·1·25
·1·875
·2·5
·3·5
·4·375
·5·625
·6·25
·6·875
·7·5
·8·125
·8·75
·9·375
·10·0625
·10·625
·11·25
·11·875
·12·5
·13·125
·13·75
·14·375
·15·0625
·15·625
·16·25
·16·875
·17·5
·18·125
·18·75
·19·375
·20·0625
·20·625
·21·25
·21·875
·22·5
·23·125
·23·75
·24·375
·25·0625
·25·625
·26·25
·26·875
·27·5
·28·125
·28·75
·29·375
·30·0625

2″ PICKERING GOVERNOR FOR STEAM ENGINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Casing for Throttle and Stop Valves	Cast Iron	1	101
2	Connecting Flange for Casing	,,	1	102
3	Throttle Valve . . .	Gun Metal	1	103
4	Stop Valve	,,	1	104
5	Seats for Throttle Valve .	,,	2	105
6	Seat for Stop Valve . .	,,	1	106

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
7	Stop Valve Spindle . .	Gun Metal	1	107
8	,, Nut . . .	,,	1	108
9	Gland for Stop Valve Spindle	,,	1	109
10	,, Nut	,,	1	110
11	Hand Wheel	Cast Iron	1	111
12	Stop Valve Cover . . .	Gun Metal	1	112
12A	Grub Screw for Hand Wheel	Mild Steel	1	$\frac{1}{4}$″ dia. $\frac{3}{8}$″ long

On this and the two succeeding plates various partial assembly and detail views are given of the well-known Pickering Governor. In this type of governor the drive is by belt from a pulley on the main shaft of the engine to the pulley (item **25**). Through the medium of the bevel gear (item **14**) the spring carriers (**36** and **37**) are caused to revolve, and the balls (item **42**) move outwards by the action of centrifugal force, bending the steel strips (**41**) to which they are attached. By this means the top nut (**35**) on the spindle (**31**) presses the spindle downwards, and actuates the throttle valve (**3**) which **governs** the passage of the steam. The speed at which the governor comes into action may be regulated by means of the spring (**24**), the tension of which is controlled by the worm (**21**) and wheel (**22**). The spring acts on the forked lever (**20**) which, by means of the collar (**16**) with which it engages, resists the downward movement of the spindle. The stroke of the throttle valve is $\frac{11}{16}$″.

Example 56.—Make full size detail working drawings of each of the following items: **1**, **2**, **7**, **11**, and **12**.

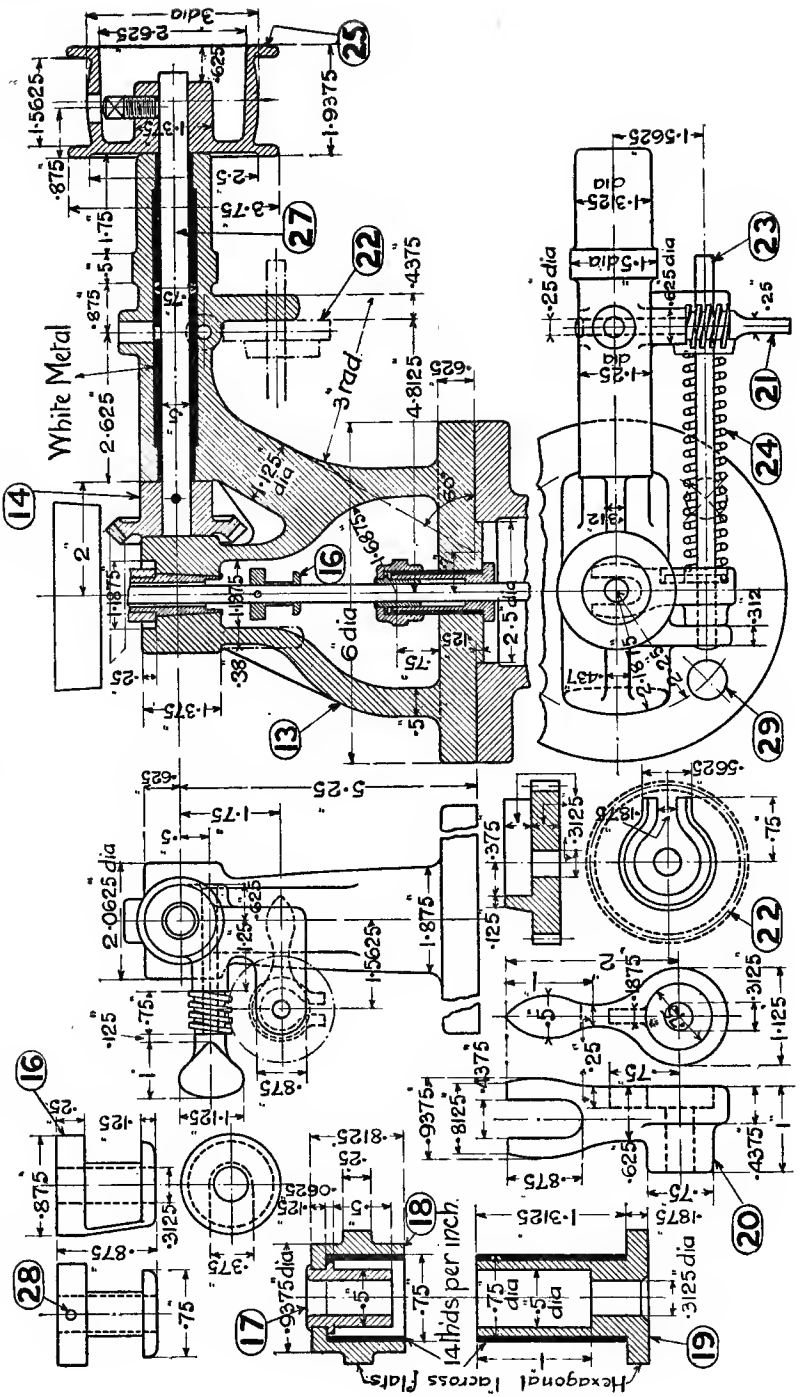
Note.—The shoulder at the extreme end of the valve spindle (item **7**) is $1\frac{1}{16}$″ diameter, and $\frac{3}{32}$″ thick, leaving $\frac{1}{32}$″ clearance between the valve and the end of the spindle. No clearance is shown in the illustration.

The flanges marked A have each four holes suitable for bolts $\frac{5}{8}$″ diameter, equally spaced on a circle $4\frac{1}{2}$″ diameter.

Other dimensions which may be required, and which have been omitted in the illustration to save overcrowding, may be scaled, the illustration being drawn accurately to scale.

Example 57.—Draw to a scale of half full size a general arrangement of the complete governor, showing two elevations and a plan. Make one elevation sectional corresponding to the sectional views given on the illustrations.

PLATE No. 33



2″ PICKERING GOVERNOR FOR STEAM ENGINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
13	Top for Throttle Valve Casing	Cast Iron	1	113
14	Bevel Wheel (32 teeth, 2⅜″ pitch circle dia., ⅜″ face)	,,	1	114
15	Taper Pin for Bevel Wheel .	Mild Steel	1	⅛″ dia. 1½″ long
16	Coupling	Cast Iron	1	115
17	Gland for Throttle Valve Spindle	Gun Metal	1	116
18	Gland Nut for Throttle Valve Spindle	,,	1	117
19	Stuffing Box for Throttle Valve Spindle	,,	1	118
20	Speeder Lever . .	Cast Iron	1	119

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
21	Worm, ¾″ Outs. Dia. (with steel spindle cast in)	Cast Iron	1	120
22	Worm Wheel (30 teeth, $\frac{5}{16}$″ pitch)	,,	1	—
23	Worm Wheel Spindle . .	Mild Steel	1	$\frac{5}{16}$″ dia. 6⅜″ long
24	Helical Spring .	Spring Steel	1	4¾″ long at rest
25	Pulley	Cast Iron	1	121
26	Sq. Hd. Set Screw for Pulley	Mild Steel	1	$\frac{3}{8} \times \frac{5}{8}$″
27	Spindle	,,	1	½″ dia. 10″ long
28	Pin for Coupling . . .	,,	1	$\frac{1}{16}$″ dia. 1″ long
29	Studs for Casing Top (screwed ⅝″ and $\frac{7}{16}$″)	,,	4	⅜″ × 2″
30	Hex. Nuts for Studs .	,,	4	⅝″

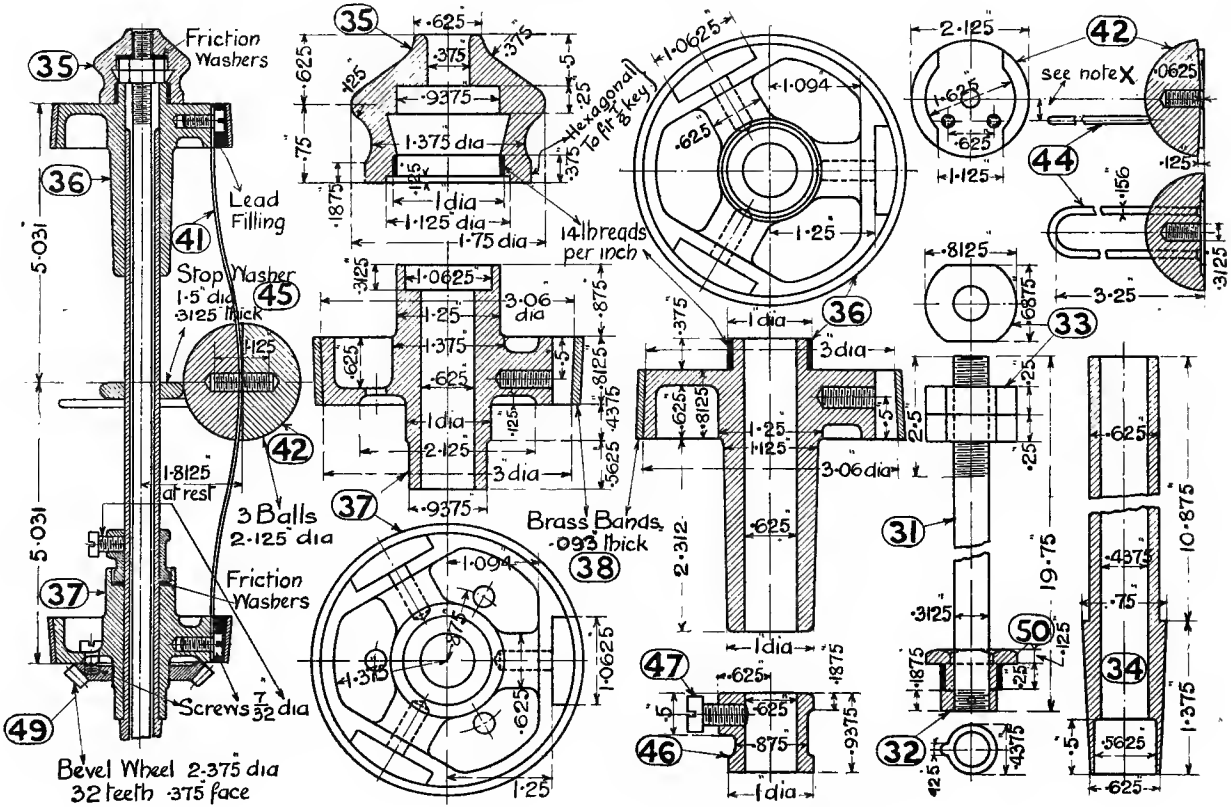
The working of the Governor is described on page 75. The details indicated on this plate are to be shown in their working positions on the general arragement drawing Example (57) on page 75.

Note.—The speed of the pulley spindle (27) is 420 r.p.m.

Example 58.—Make full size detail working drawings of items **13** and **14**.

Example 59.—Trace the drawing made to Example 58.

PLATE No. 34


Friction Washers
Lead Filling
Stop Washer 1·5 dia ·3125 thick
1·8125 at rest
3 Balls 2·125 dia
Friction Washers
Screws 7/32 dia
Bevel Wheel 2·375 dia 32 teeth ·375 face
Hexagonal to fit 8 key
14 threads per inch
Brass Bands ·093 thick
see note X
1 dia
1·125 dia
1·75 dia
3·06 dia
3 dia
1·25
1·094
1·0625
·9375
·625
·375
·5
·25
·125
·1875
·3125
·4375
·6875
·8125
·875
·156
2·125
3·25
5·031
2·312
19·75
10·875
1·375
35
36
37
38
41
42
44
45
46
47
49
50
31
32
33
34

2″ PICKERING GOVERNOR FOR STEAM ENGINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
31	Throttle Valve Spindle . .	Gun Metal	1	$\frac{5}{16}$″ dia. 19$\frac{3}{4}$″ long
32	Collar for Throttle Valve Spindle	,,	1	122
33	Adjusting Nuts for Collar for Throttle Valve Spindle	Cast Iron	2	123
34	Centre Tube	Steel	1	—
35	Top Nut	Cast Iron	1	124
36	,, Spring Carrier . .	,,	1	125
37	Bottom Spring Carrier . .	,,	1	126
38	Bands for Bottom Spring Carrier	Brass	2	—
39	Cheese Hd. Screws for Fixing Springs	Mild Steel	6	$\frac{7}{32}$″ × $\frac{5}{8}$″
40	Cheese Hd. Screws for Fixing Bevel Wheel	,,	3	$\frac{7}{32}$″ × $\frac{7}{16}$″

Ref. Number	Description.	Material.	Number Reqd.	Pattern No. or Size.
41	Spring Strips (5 per spring) .	Steel	15	1$\frac{1}{16}$″×·01325″×10″
42	Balls (in halves) . . .	Cast Iron	3	127
43	Studs for Balls (screwed whole length)	Mild Steel	6	$\frac{5}{16}$″ × 1$\frac{1}{4}$″
44	Links for Balls . . .	Steel	3	—
45	Stop Washer	Cast Iron	1	128
46	Collar	,,	1	129
47	Cheese Hd. Screw for Collar .	Mild Steel	1	$\frac{7}{32}$″ × $\frac{1}{2}$″
48	Friction Washers . . .	Phosphor Bronze	4	$\frac{1}{8}$″ dia. ·01″ thick
49	Bevel Wheel (32 teeth, $\frac{3}{8}$″ face, 2$\frac{3}{8}$″ pitch circle dia.)	Cast Iron	1	130
50	Coupling Nut (screwed part $\frac{3}{16}$″ dia., hex. part 1$\frac{1}{16}$″ across flats)	Gun Metal	1	131

Further details of portions of the Pickering Governor are given on the plate facing this page.

The working of the governor is explained on page 75. All the details shown on this plate are to be indicated in their working positions on the general arrangement drawing called for on page 75.

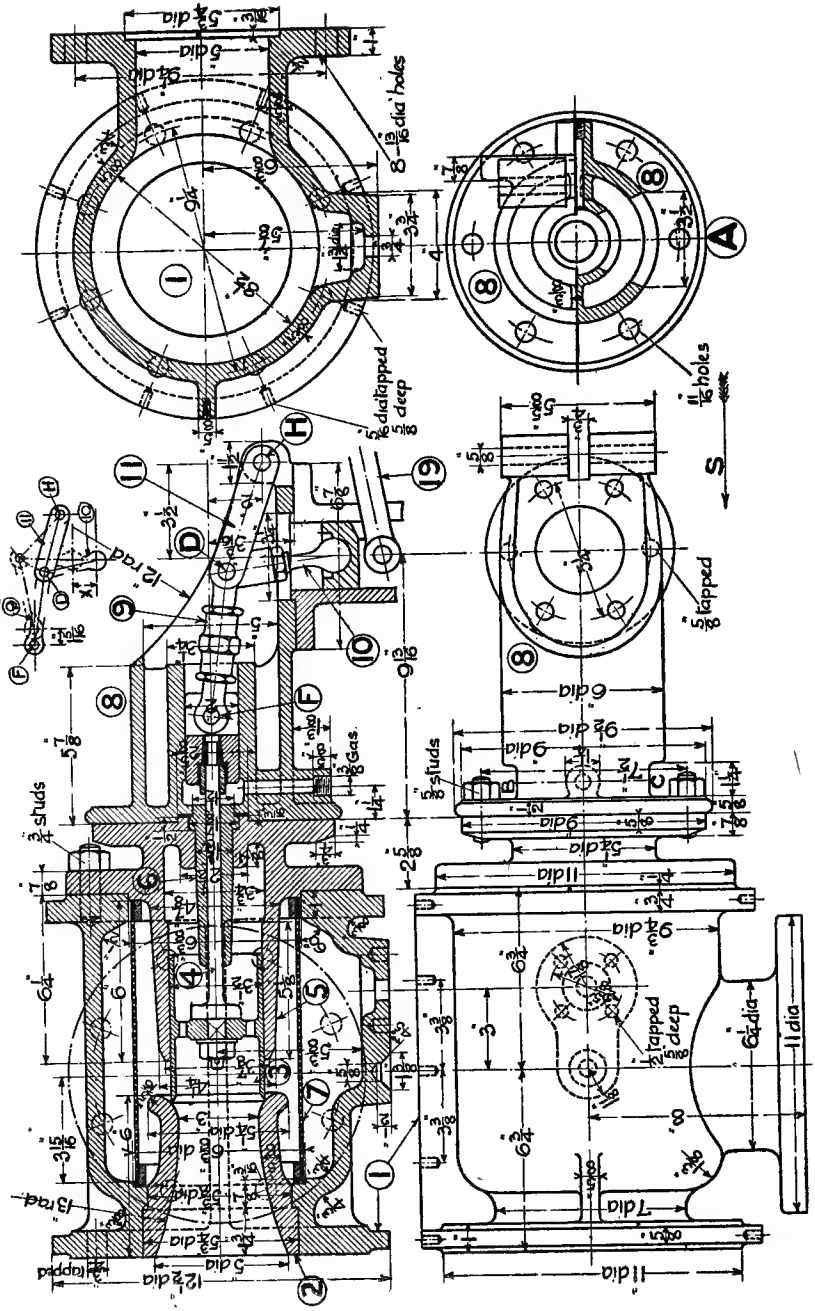
Note X.—On two of the balls (item 42) the dimension from the centre of the ball to the centre of the link is $\frac{3}{8}$″. On the third ball this dimension is $\frac{1}{32}\frac{7}{}$″.

It will be noted that the dimensioning on the three plates illustrating the governor has been done in decimals. The result does not justify the conversion of $\frac{1}{32}$ths, $\frac{1}{16}$ths, $\frac{1}{8}$ths, and so on, the space occupied by the actual figures being greater when decimals are used than when ordinary fractions are used.

The decimal system, however, is infinitely more convenient for dimensioning purposes if sizes are confined to hundredths and multiples thereof.

Example 60.—Trace the drawing made to Example 57.

PLATE No. 35


8 - 13/16 dia holes
5/8 dia tapped 5/8 deep
5/8 tapped
5/8 studs
3/4 studs
3/8 Gas.
12 rad
13 rad
11 dia
9 1/2 dia
7 dia
6 dia
5 dia
5 1/2 dia
12 1/2 dia
S

GOVERNOR GEAR DETAILS FOR STEAM TURBINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Throttle Valve Box	Cast Steel	1	750
2	Nozzle	,, Iron	1	751
3	Throttle Valve	Nickel Steel	1	—
4	,, ,, Spindle	,,	1	—
5	,, ,, Guide	Cast Iron	1	752
6	Valve Spindle Guide	,,	1	753

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
7	Strainer	Wro't Iron	1	—
8	Bracket for Toggle Gear	Cast Iron	1	754
9	Connecting Rod	Mild Steel	1	—
10	Ball Rod	,,	1	—
11	Toggle Lever	,,	1	—

A portion of the Governor Gear for a Brush-Ljungström Turbine is illustrated on the plate facing this page, further details being shown on Plate No. 36.

The function of the gear is, of course, to control the supply of steam to the turbine. This is accomplished by means of the throttle valve (**3**) which is actuated by toggle gear, consisting of the connecting rod (**9**), the ball rod (**10**), and the lever (**11**). The ball rod receives its up and down motion through the agency of the piston of a relay cylinder, the action of which is described on the succeeding page.

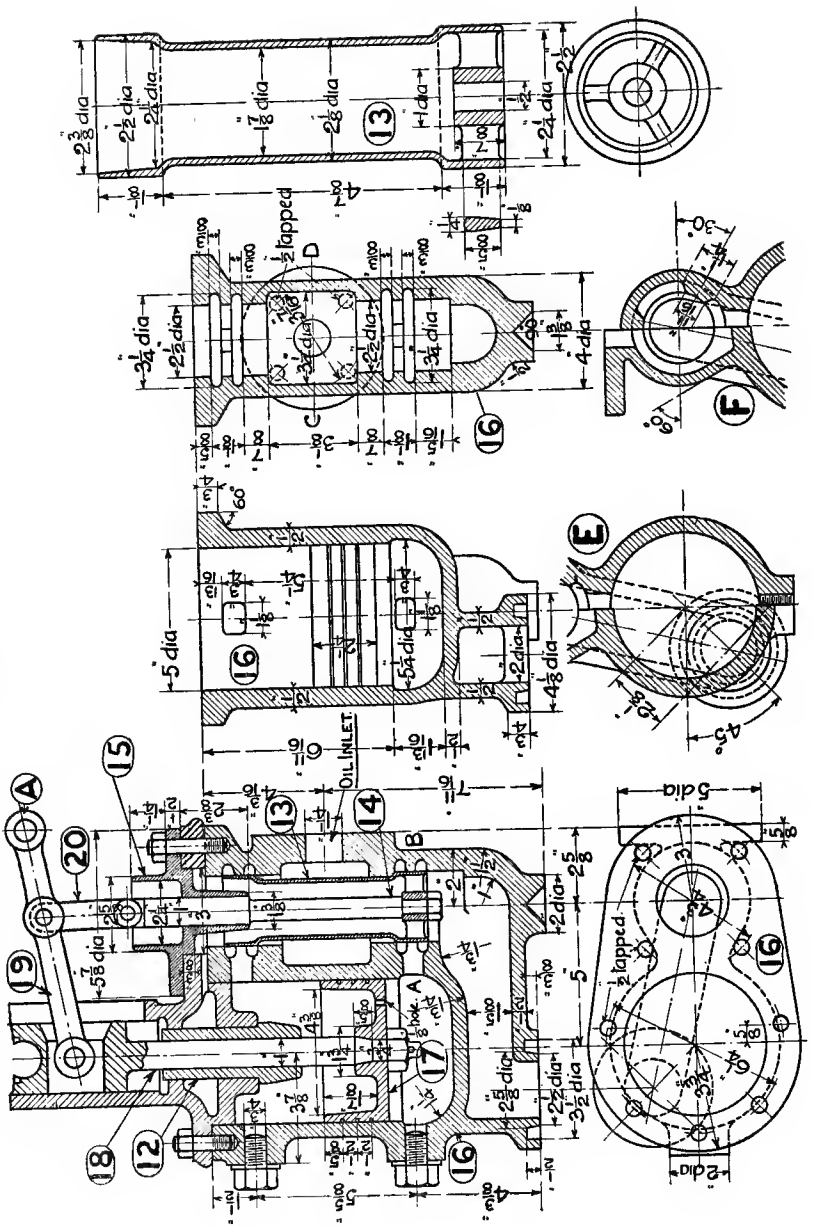
The toggle gear is arranged so that the steam adjustment is much finer with the throttle nearly closed than when it is wide open. The end D of lever (**11**) swinging about centre H carries the throttle valve to the right, but with the valve nearly closed the swing of the connecting rod (**9**) about centre F partly neutralises this motion. When the rod (**9**) rises above the horizontal the motion due to its swing adds to that due to the swing of the lever. The rod (**9**) consists of two short ends coupled together by a turnbuckle and lock nuts. The screwed portions of these ends inside the turnbuckle are finely threaded, thus facilitating minute adjustment of the valve travel. The small diagrammatic sketch at the top of the plate illustrates the movement of the toggle gear. The full lines show the position when the throttle valve is closed and the dotted lines the position when the valve is full open. The travel of the valve is $1\frac{5}{16}''$, and dimension X indicates the travel of the relay piston.

The end view A of the toggle lever bracket (**8**) is taken looking in the direction indicated by the arrow S. The lower half of the view is a section on the line BC.

Example 61.—Make separate detail working drawings of each of the following items: **1**, **2**, **5**, and **8**. To be dimensioned in millimetres working to the nearest half-millimetre.

Example 62.—Trace the drawing made to Example 61.

PLATE No. 36



GOVERNOR GEAR DETAILS FOR STEAM TURBINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
12	Piston Rod Guide . . .	Cast Iron	1	817
13	Relay Valve	,,	1	818
14	,, ,, Spindle . .	Mild Steel	1	—
15	,, ,, ,, Guide .	Cast Iron	1	819
16	,, Cylinder and Valve Chest	,,	1	820

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
17	Relay Cylinder Piston . .	Cast Iron	1	821
18	,, ,, ,, Rod .	Mild Steel	1	—
19	Actuating Lever . .		1	—
20	Connecting ,, . . .	,,	1	—

Some further details of the actuating gear of the Governor for a Brush-Ljungström Turbine are shown on this plate. The action of the gear is as follows: The end A of lever (19) is attached to, and moves up and down with, the sleeve of a centrifugal governor which is driven direct from the turbine shaft. This sleeve and centrifugal governor are not shown.

When the turbine is at rest, "A" is in its **lowest** position, and consequently the oil valve (13) is also in its lowest position, which is somewhat lower than it is shown in the illustration.

With the valve in the lowest position, oil under pressure is admitted to the lower part of the relay cylinder (16), and the relay piston (17) is forced upwards. This movement is transmitted through the toggle gear, and the throttle valve opens, as explained on the previous page. As the relay piston moves upwards, it forces the oil valve back to its central position through the agency of the lever (19) and the link (20), thus cutting off the oil supply from below the relay piston.

As the turbine speed increases, the centrifugal governor comes into action, the end A of lever (19) is lifted, and the valve (13) raised **above** its central position. Pressure oil is then admitted **above** the relay piston, forcing the piston downwards, which causes the throttle valve to commence closing. The throttle would be entirely closed, but that the oil valve is again forced to its central position. The throttle valve is thus adjusted to admit exactly the quantity of steam required by the turbine at any load. A small hole is drilled through the relay piston to prevent shock when the oil valve closes.

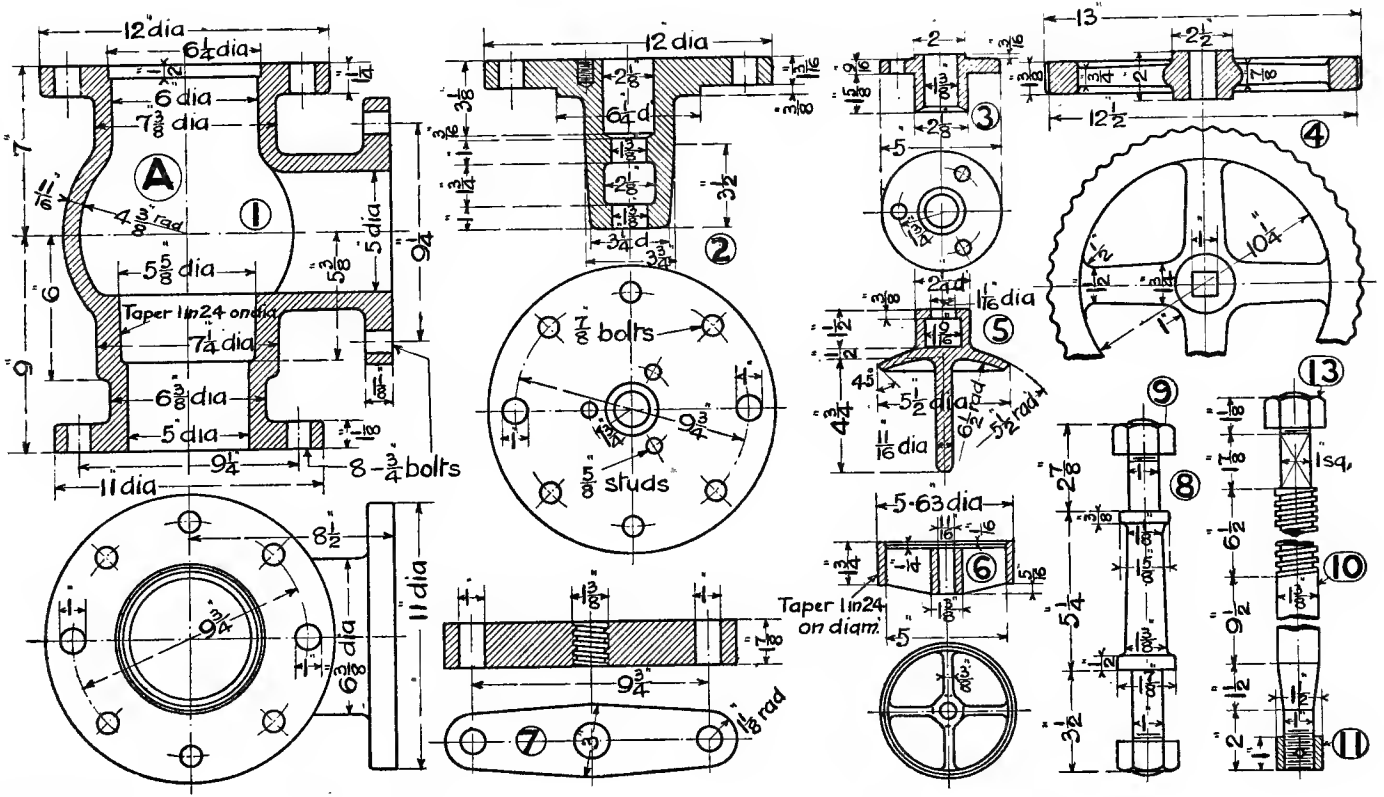
In the views E and F of the relay cylinder, the left-hand halves are sections on CD, and the right-hand halves sections on AB.

Example 63.—Make separate detail working drawings of each of the following items: **15** and **16**. To be dimensioned in millimetres, working to the nearest half-millimetre.

SECTION IV

STEAM BOILERS AND BOILER MOUNTINGS

PLATE No. 37


12 dia
6¼ dia
6 dia
7⅞ dia
A
1
4⅜ rad
5⅝ dia
5 dia
9¼
7
6
9
Taper 1 in 24 on dia
7¼ dia
6⅜ dia
5 dia
8 – ¾ bolts
11 dia
12 dia
6¼ d
2
7/8 bolts
9¾
studs
8½
9¾
6⅜ dia
11 dia
7/8
9¾
1⅛ rad
7
3
2
3
5
1⅛ dia
13
2½
12½
4
10¼
1½
1
5
1⅛ dia
4½
5½ dia
6½ rad
5½ rad
4¾
1⅛ dia
5·63 dia
6
Taper 1 in 24 on diam.
5
9
8
2⅞
5¼
3½
13
1 sq.
10
11
6½
9½
2

5″ STEAM STOP VALVE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Body	Cast Iron	1	301
2	Cover and Stuffing Box	,,	1	302
3	Gland	Gun Metal	1	303
4	Hand Wheel	Cast Iron	1	304
5	Valve	Gun Metal	1	305
6	,, Seating	,,	1	306
7	Cross-bar Nut	Wro't Iron	1	12″ × 3″ × 1⅛″
8	Standards	Mild Steel	2	—
9	Hex. Nuts for Standards	,,	4	1″
10	Spindle	Gun Metal	1	—
11	Square Nut for Spindle	Mild Steel	1	1½″ square 1″ thick
12	Pin for Square Nut for Spindle	,,	1	¼″ × 1½″
13	Hex. Nut for Spindle	,,	1	1″
14	Studs for Gland (screwed 1⅜″ and ⅞″)	,,	3	⅝″ × 3″
15	Hex. Nuts for Studs	,,	3	⅝″
16	,, Hd. Bolts for Cover	,,	6	⅝″ × 3½″
17	,, Nuts for Bolts for Cover	,,	6	⅝″

Details of a 5″ Steam Stop Valve of the screw-down type are given on this plate. Such valves are used for regulating the supply of steam from a boiler to an engine.

Example 64.—Make a drawing (scale, half size) showing all the parts assembled together in their actual working positions. Give two elevations and a plan making one elevation in section corresponding to the view **A**.

The following order of drawing is suggested:—

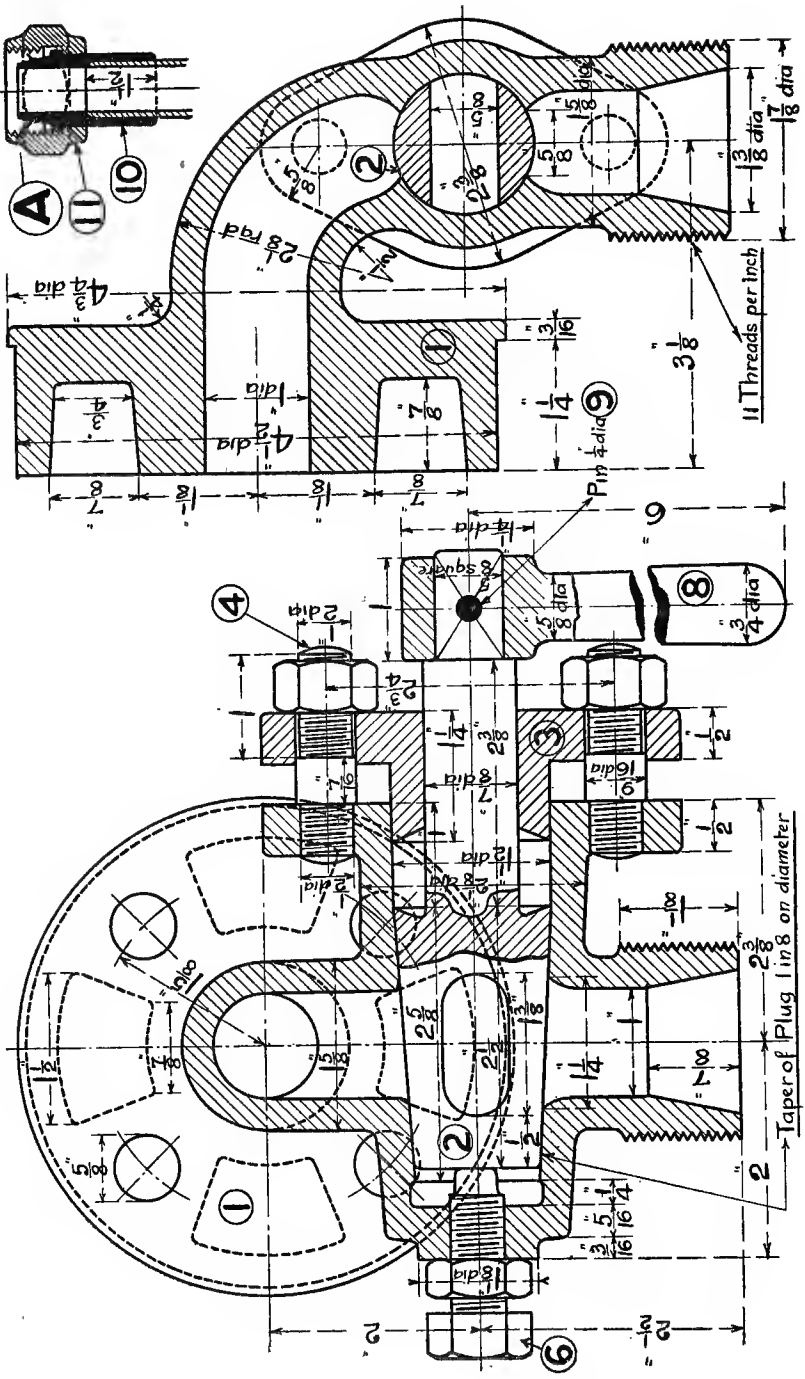
(1) Body. Item **1**. (When assembled, the total height of the valve over-all is about 30″. Take this into account when deciding on the position of the body on your paper.)
(2) Seating. Item **6**.
(3) Valve. Item **5**.
(4) Spindle. Item **10**.
(5) Cover and stuffing box. Item **2**.
(6) Gland. Item **3**.
(7) Standards. Item **8**.
(8) Cross-bar. Item **7**.
(9) Hand wheel. Item **4**.
(10) Bolts, studs, nuts, etc.

Note.—The square nut (item **11**) is placed in the rectangular opening in the upper portion of the valve (item **5**). The opening is $1\frac{9}{16}$″ wide, and extends through the casting. The spindle (**10**) is then screwed into the nut, a hole $1\frac{1}{16}$″ diameter in the casting being made to allow of this being done.

Example 65.—Design a 4″ valve similar to the one illustrated.

Example 66.—Trace the drawing made to Example 64 or 65.

PLATE No. 38


Taper of Plug 1 in 8 on diameter
11 Threads per inch
Pin ¼ dia
8 square
2 dia
1½ dia
1 dia
A
10
11

SCUM COCK FOR LOCOMOTIVE BOILER

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Body	Gun Metal	1	1186
2	Plug	,,	1	1187
3	Gland	,,	1	1188
4	Shoulder Studs	Mild Steel	2	—
5	Hex. Nuts (double chamfered)	,,	2	$\frac{1}{2}$″
6	,, Hd. Releasing Screw	,,	1	$\frac{1}{2}$″ × $1\frac{1}{8}$″

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
7	Hex. Lock Nut (double chamfered)	Mild Steel	1	$\frac{1}{2}$″
8	Handle for Plug	Wro't Iron	1	—
9	Tapered Pin	Mild Steel	1	$\frac{1}{4}$″ to $\frac{5}{16}$″ dia. 2″ long
10	Sleeve for Union	Gun Metal	1	1189
11	Union Nut	,,	1	1190

Sectional views of a Scum Cock are given on this plate.

The water supply available for service is sometimes of such a nature that a large amount of sediment or scum is constantly forming, and, if allowed to accumulate, has a deleterious effect on the boiler plates and joints. The cock shown in the illustration provides a convenient means of getting rid of the scum. The cock is fixed to the back plate of the boiler (within convenient reach of the driver) by means of four $\frac{1}{2}$″ studs screwed directly into the boiler plate. The "clothing" or lagging of the boiler being in this instance about $1\frac{1}{8}$″ thick, the flange on the body of the scum cock is made sufficiently thick to project through the clothing plate to facilitate fixing. The flange is lightened by reason of the four recesses which are cored on the underside.

A carrying-off pipe is connected to the outlet of the cock by means of a union, this connection being shown in the auxiliary view A. A sleeve (**10**) is brazed on to the carrying-off pipe, and has its coned end fitting the conical opening in the outlet of the cock, being held thereto by the union nut (**11**).

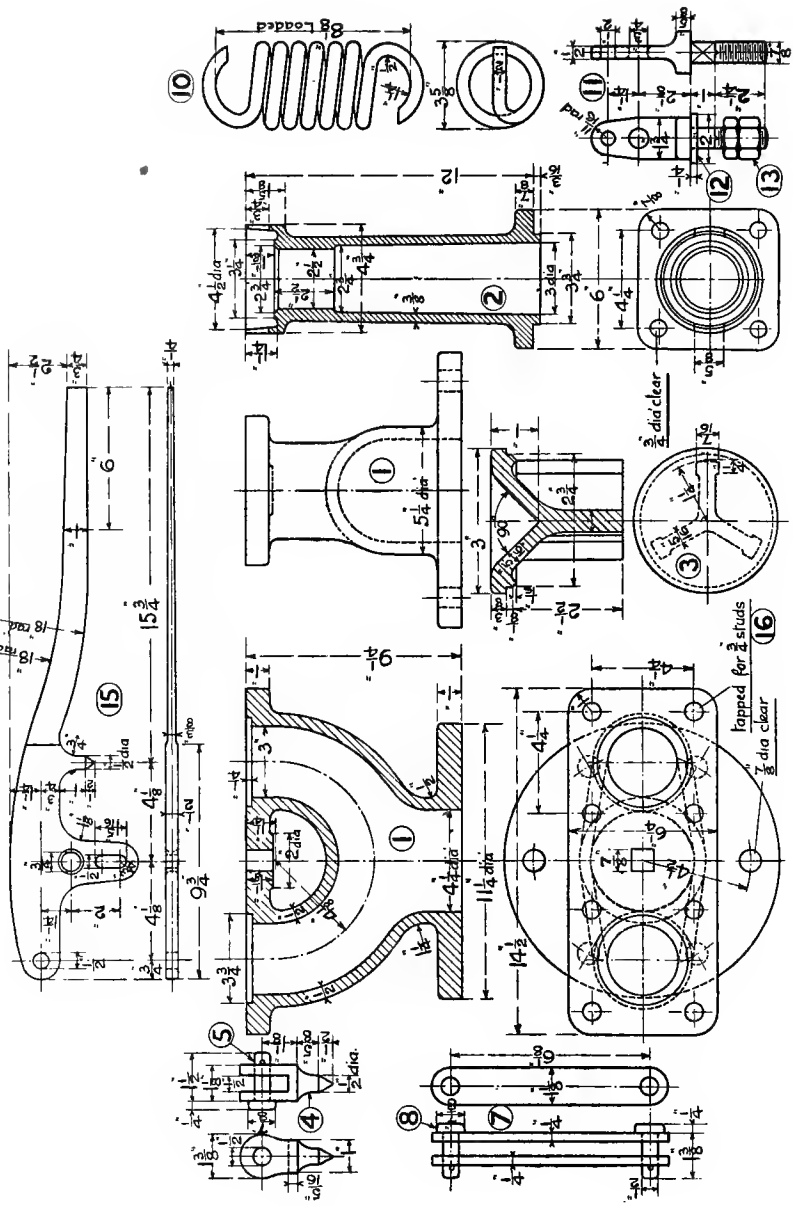
The inside diameter of the pipe is 1″; outside diameter, $1\frac{1}{4}$″; outside diameter of sleeve, $1\frac{1}{2}$″; diameter of shoulder on sleeve, $1\frac{3}{4}$″; thickness of shoulder, $\frac{1}{4}$″; length of coned portion of sleeve, $\frac{3}{4}$″; total length of sleeve, 3″.

The union nut is $2\frac{3}{4}$″ across the corners of the hexagonal part, the latter being 1″ in depth. The total length through the nut is $1\frac{3}{4}$″, and the length of sleeve projecting through the nut is $1\frac{1}{2}$″.

Example 67.—Make a separate detail working drawing of each of the following items: **1**, **2**, **3**, and **8**. **Scale, Full Size.**

Example 68.—Make a complete drawing of the whole cock as in the illustration, but showing the carrying-off pipe and connection in position in both elevations. Then project a complete plan, **Scale, Full Size.**

PLATE No. 39


8g Loaded
Tapped for ⅜ studs
⅞ dia clear
¾ dia clear
18 rad
18 rad

RAMSBOTTOM SAFETY VALVE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Seating	Cast Iron	1	1562
2	Columns	,,	2	1563
3	Valves	Gun Metal	2	1564
4	Fulcrum Bracket	Wro't Iron	1	—
5	,, Pin	Mild Steel	1	$\frac{1}{2}''$ × $1\frac{1}{2}''$
6	,, Split Pin	,,	1	$\frac{1}{8}''$ × $1\frac{1}{2}''$
7	Safety Links	,,	2	$1\frac{1}{8}''$ × $\frac{1}{4}''$ × $7\frac{1}{4}''$
8	,, ,, Pins	,,	2	$\frac{1}{2}''$ × $1\frac{3}{8}''$
9	,, ,, Split Pins	,,	2	$\frac{1}{8}''$ × $1\frac{1}{4}''$
10	Helical Spring	Spring Steel	1	—
11	Eye-bolt	Wro't Iron	1	—
12	,, Washer	,,	1	2″ dia. $\frac{1}{4}''$ thick
13	Hex. Nut (double chamfered)	Mild Steel	1	$\frac{1}{2}''$
14	,, Lock (double chamfered)	,,	1	$\frac{7}{8}''$
15	Lever	Wro't Iron	1	—
16	Studs for Fixing Columns (screwed 1″ each end)	Mild Steel	8	$\frac{3}{4}''$ × $2\frac{3}{4}''$
17	Hex. Nuts	,,	8	$\frac{3}{4}''$

Complete details of a Locomotive Safety Valve of the familiar Ramsbottom pattern are given on this plate.

The seating (item **1**) is studded to a wrought-iron seating, which is itself riveted to the boiler shell. Two cast-iron columns (item **2**) are fixed to the seating (item **1**) by means of the studs and nuts (items **16** and **17**). The valves (item **3**) rest on the seatings formed in the upper part of the columns, and are held thereon by the spring through the agency of the fulcrum bracket (item **4**) and the fulcrum point formed on the lever (**15**). In the centre of the upper flange of the seating is a square hole into which is fitted the eye-bolt (**11**). The lever is connected to this bolt by the spring, the hooked ends of which are passed through the $\frac{3}{4}''$ holes in the lever and eye-bolt. Safety links (item **7**) are provided, so that in the event of the spring breaking the valves are prevented from being blown away. These links are fastened to the eye-bolt and the lever by $\frac{1}{2}''$ pins, the pins in the lever passing through the elongated hole so as not to interfere with the action of the spring.

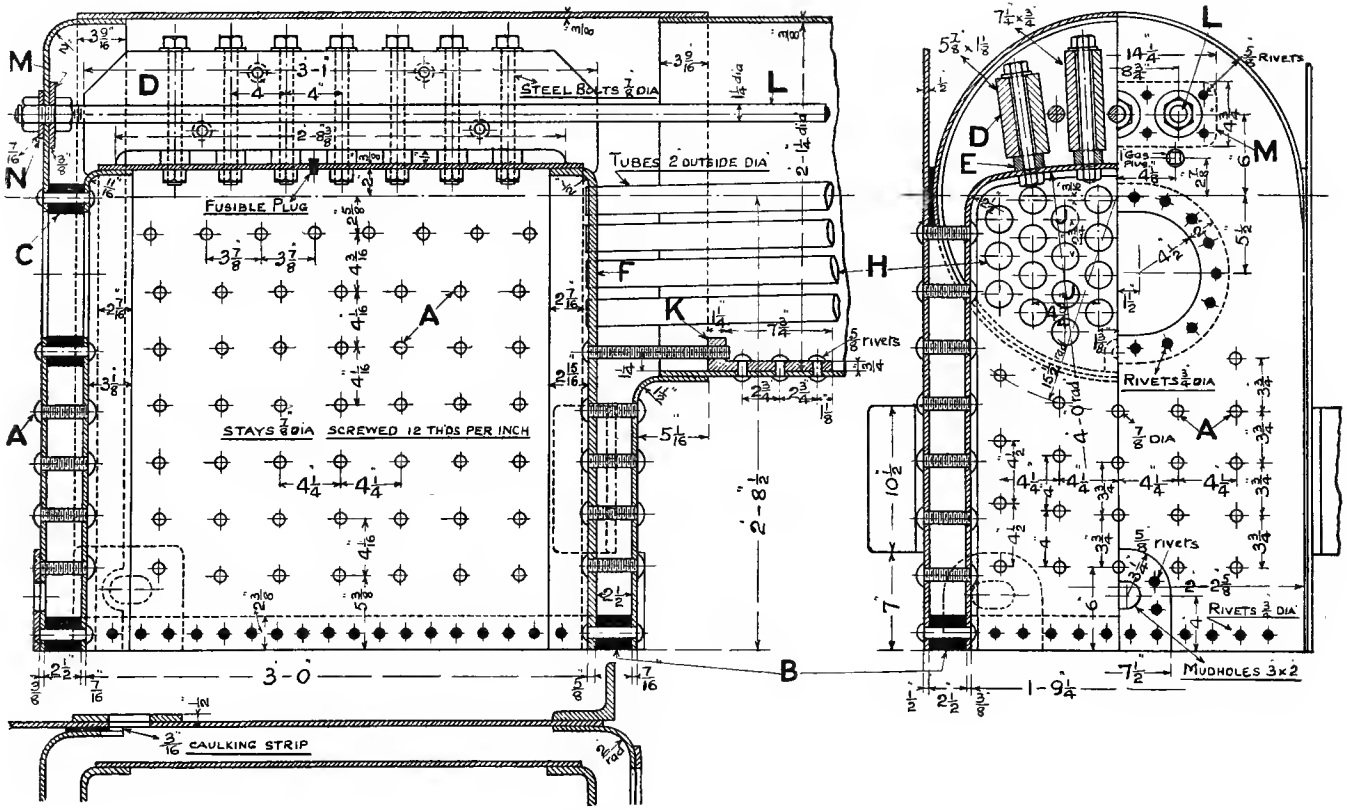
Example 69.—Make a drawing to scale (half full size) showing all the parts assembled together in their working positions. Two elevations and a plan are to be shown, and the views are to correspond with the three views given of item **1**.

The following order of drawing is suggested: (**1**) Seating. (**2**) Columns. (**3**) Valves. (**4**) Fulcrum bracket on left-hand valve. (**5**) Lever. (**6**) Eye-bolt. (**7**) Spring. (**8**) Safety links. (**9**) Studs, etc.

The spring may be drawn in the conventional manner indicated in the illustration.

Example 70.—Trace the drawing made to Example 69.

PLATE No. 40


STEEL STAYS 7/8 DIA
TUBES 2 OUTSIDE DIA
FUSIBLE PLUG
STAYS 7/8 DIA SCREWED 12 THDS PER INCH
CAULKING STRIP
RIVETS
RIVETS 3/4 DIA
7/8 DIA
MUDHOLES 3 x 2
A
B
C
D
E
F
H
J
K
L
M
N
3-0
1-9 1/4
4 - 0 rad
2 - 8 1/2"

FIRE-BOX OF TRACTION ENGINE BOILER

The illustration given on the opposite page shows the Fire-box of a Traction Engine Boiler.

The plates of the outer shell are of steel, and those of the inside box, of copper. The side plates of the shell are shown broken. The extended portions (not shown) are utilized for supporting the engine driver's "house". The inside box is connected to the shell by means of a large number of copper stays (A).

These stays are screwed into both the shell plate and the box plate, and then have heads formed by riveting.

At the bottom edge of the box and shell there is a foundation ring (B), $2\frac{1}{2}''$ square in section, going all round the box. This ring is riveted to the shell and the box as indicated. Where the holes are cut in the plates for the "fire-hole" the plates are strengthened by a ring (C) $2\frac{1}{2}'' \times 2''$ rectangular section, which is also riveted to box and shell.

The roof of the copper box is stiffened by means of four roof stays (D) extending over the full length of the roof, each stay attached thereto by means of seven $\frac{7}{8}''$ bolts. These bolts are screwed into the roof plate, and are fitted with lock nuts inside the box. The roof stays themselves each consist of two wrought-iron bars riveted together with distance collars between which keep the bars $\frac{15}{16}''$ apart. This provides a clear passage for the bolts. The ferrules between the roof and the lower edges of the roof stays prevent any buckling of the roof plate when the bolts are screwed home.

The tube plate of the fire-box (F) is connected to the tube plate of the smoke-box (not shown) by 30 tubes (H). Four of these tubes (J) are screwed and nutted at each end to act as stays. Further staying of this plate is provided by the palm stay (K).

The back plate of the outer shell is stayed to the smoke-box tube plate by means of three $1\frac{1}{4}''$ stays (L). These stays are screwed into the smoke-box tube plate and fitted with a standard hexagonal nut on the outside, with a washer $3\frac{3}{4}''$ diameter by $\frac{7}{16}''$ thick under the nut.

At the fire-box end the stays pass through clearance holes in the shell plate, the shell being re-inforced by a rectangular plate (M), which is riveted to it. The stays at this end have nuts both on the inside and outside of the box, as well as a washer (N) on the outside. Between the outside washer and the shell plate a thin copper ring is placed with the object of making the joint steam tight.

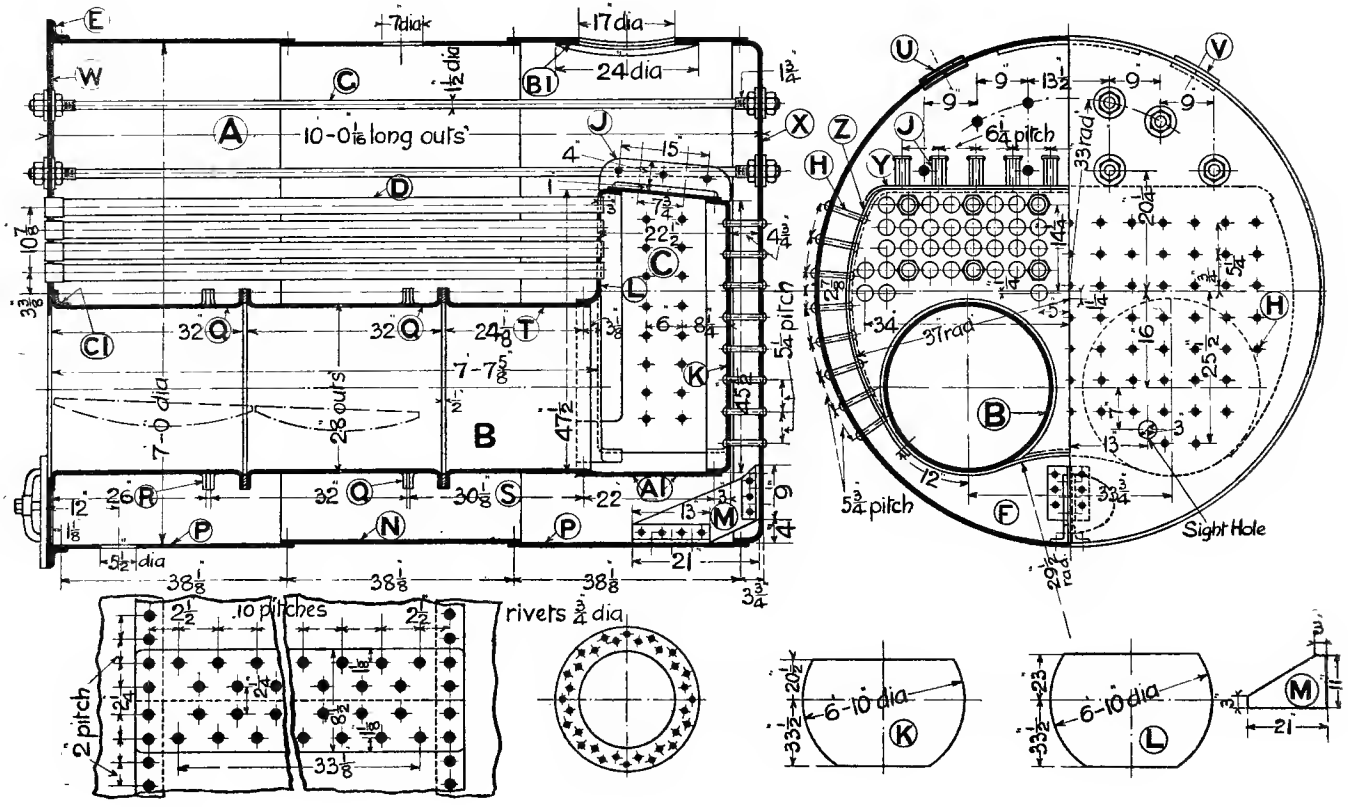
The fusible plug, shown in the roof plate of the fire-box, is a safety device for the protection of the box. It is made of brass, and has the centre portion drilled or cored out, and filled with white metal having a low melting-point.

If, through any means, the water supply in the boiler gets too low, this white metal melts and the fire is extinguished by the inrushing water and steam.

EXAMPLE 71.—Separate detail working drawings are to be made of each of the following items: (1) The tube plate (F). (2) The roof stays (D), with bolts, etc., complete. (3) The palm stay. (4) The longitudinal stay.

The ends only of the longitudinal stay need be shown. In each case the plates to which these parts are attached must be shown.

PLATE No. 41


A
B
C
D
E
F
H
J
K
L
M
N
P
Q
R
S
T
U
V
W
X
Y
Z
10-0 1/16 long outs
7-7 5/8 outs
7-0 dia
24 outs
7 dia
17 dia
24 dia
6 1/4 pitch
5 3/4 pitch
Sight Hole
10 pitches
2 pitch
rivets 3/4 dia
6-10 dia

MARINE TYPE BOILER

A small Marine Boiler is shown on the plate facing this page.

Inside a cylindrical outer shell (A) are two cylindrical furnaces (B) leading into a combustion chamber (C). The shell, furnaces, and chamber are all built up of steel plates, the thicknesses and sizes of which are tabulated on p. 96. Connecting the combustion chamber to the smoke-box are 72 tubes (D). These tubes are of mild steel, and are $2\frac{3}{4}$" diameter outside, swelled to $2\frac{7}{8}$" diameter where they fit the smoke-box tube plate. The tubes are ferruled at the combustion chamber end. Twelve of these tubes are screwed into both tube plates to act as stays, and are fitted with lock nuts as shown.

The angle ring (E) connecting the outer shell to the smoke-box tube plate is 3" × 3" × $\frac{1}{2}$" section. A gusset stay (F) and (M) stiffens the connection between the back plate and the shell.

There are eight longitudinal stay bolts (G), $1\frac{1}{2}$" diameter, screwed $1\frac{3}{4}$" diameter at the ends, and fitted with nuts and washers (the washers being $5\frac{1}{4}$" diameter × $\frac{1}{2}$" thick), both on the inside and outside of the shell.

The combustion chamber is secured to the outer shell by means of 107 $\frac{7}{8}$" screwed stays (H), (best wrought iron). On the top of the combustion chamber there are ten bridge stays (J), each consisting of two iron bars, 4" × $\frac{5}{8}$", riveted together by means of $\frac{3}{4}$" rivets, with ferrules between the bars. The stays are fixed to the top plate of the chamber by $\frac{7}{8}$" studs, screwed into the plate, and fitted with nuts and washers at each end. There are two studs for each bridge stay. The washers on top of the bridge stays are $2\frac{3}{4}$" square × $\frac{1}{4}$" thick.

There is a manhole, 17" diameter, in the shell over the combustion chamber, and an oval manhole, 14" × 10", in the front shell plate, situated on the centre of the boiler. Over the 7" hole in the top of the shell centre ring is fixed a seating carrying a dome on which are mounted a 5" steam stop valve, a $2\frac{1}{2}$" lever safety valve and a $2\frac{1}{2}$" spring safety valve.

The $5\frac{1}{2}$" diameter hole at the front end of the shell below the furnaces is the outlet to the blow-off tap, which is fixed to a seating on the shell at this point.

EXAMPLE 72.—(*a*) Make a working drawing of the boiler shell, showing all the joints and riveting, all stay and tube holes, but no stays or tubes.

(*b*) Make a full size working drawing of the bridge stays.

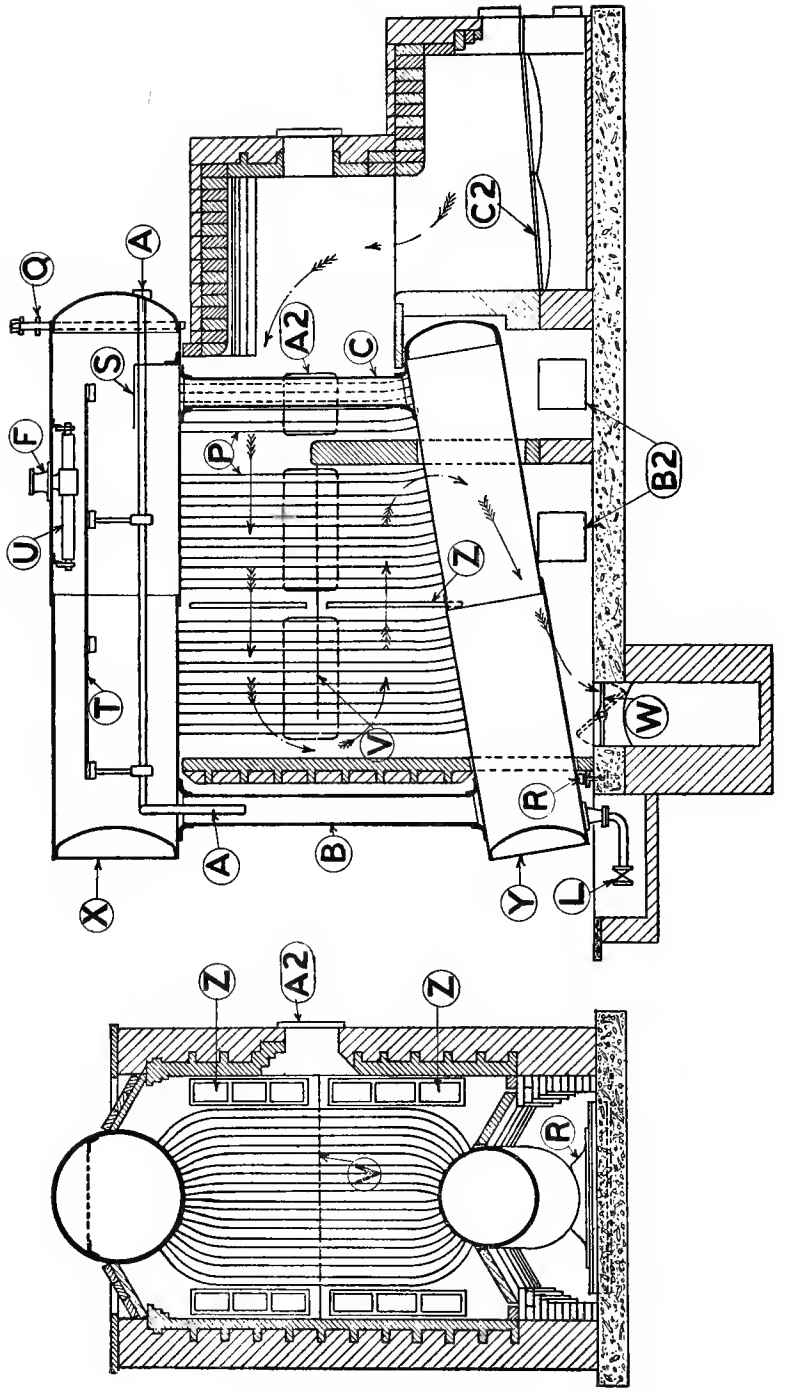
(*c*) Make a full size drawing of the gusset stay.

MARINE TYPE BOILER (*continued*)

LIST OF STEEL PLATES REQUIRED

Reference Letter.	Size or Shape of Plate.	Number Required.
K	$\frac{1}{32}$″ thick. For shape, see illustration.	1
L	$\frac{5}{8}$″ ,, ,, ,, ,,	1
M	$\frac{7}{16}$″ ,, ,, ,, ,,	1
N	21′—10$\frac{3}{4}$″ × 3′—4$\frac{3}{8}$″ × $\frac{1}{2}$″	1
P	22′—1$\frac{7}{8}$″ × 3′—4$\frac{3}{8}$″ × $\frac{1}{2}$″	2
Q	7′—3$\frac{1}{4}$″ × 3′—1$\frac{3}{8}$″ × $\frac{13}{32}$″	3
R	7′—3$\frac{5}{8}$″ × 2′—7$\frac{1}{8}$″ × $\frac{13}{32}$″	1
S	7′—3$\frac{1}{4}$″ × 2′—11″ × $\frac{13}{32}$″	1
T	7′—3$\frac{1}{8}$″ × 2′—5″ × $\frac{13}{32}$″	1
U	3′—4$\frac{1}{8}$″ × 8$\frac{5}{8}$″ × $\frac{3}{8}$″	4
V	3′—2″ × 8$\frac{5}{8}$″ × $\frac{3}{8}$″	2
W	7′—7$\frac{1}{4}$″ dia. × $\frac{5}{8}$″ thick	1
X	7′—6$\frac{1}{2}$″ dia. × $\frac{5}{16}$″ thick	1
Y	6′—1″ × 1′—7$\frac{1}{2}$″ × $\frac{17}{32}$″	1
Z	3′—10$\frac{1}{2}$″ × 1′—7$\frac{1}{4}$″ × $\frac{17}{32}$″	1
A1	5′—4″ × 2′—0$\frac{5}{8}$″ × $\frac{11}{32}$″	1
B1	$\frac{1}{2}$″ thick. For shape, see illustration.	1
C1	3′—0″ × 6″ × $\frac{13}{32}$″	2

PLATE No. 42



"SUCKLING" WATER-TUBE BOILER

The illustration facing this page shows the general arrangement of a "Suckling" Water-tube Boiler. As shown, the furnace is hand fired, but mechanical stokers may quite easily be applied. The boiler consists of an upper or steam drum (X) and a lower or water drum (Y). These drums are coupled together by large tubular connections (B and C), one at each end, and a number of water tubes (P).

The boiler is fixed in a manner that precludes any interference with expansion by the brickwork of the furnace. The upper drum is suspended from a steel girder (Q), and the lower drum rests on a cast-iron cradle (R). The tubular connections (B and C) act as supports, and relieve the small tubes of all strains.

Water is admitted to the boiler through the feed pipe (A), which discharges into the **downtake** (B) at the back end of the boiler. This downtake, being outside the furnace, remains comparatively cool. The front tubular connection (C) is exposed to high furnace temperature, and constitutes the **uptake**. Immediately the fire is lighted the circulation of the water commences, rising in the uptake, passing along the upper drum, thence through the downtake into the lower drum, thus completing the circuit.

The flow of the water is rapid and continuous, and always in the same direction. At the same time steam passes from the tubes into the steam drum. A cowl (S) is fixed over the uptake to deflect the steam and water, and so prevent violent splashing and spray formation at this point. An anti-priming diaphragm (T) is also fitted in the steam drum as well as an anti-priming pipe (U) beneath the stop valve.

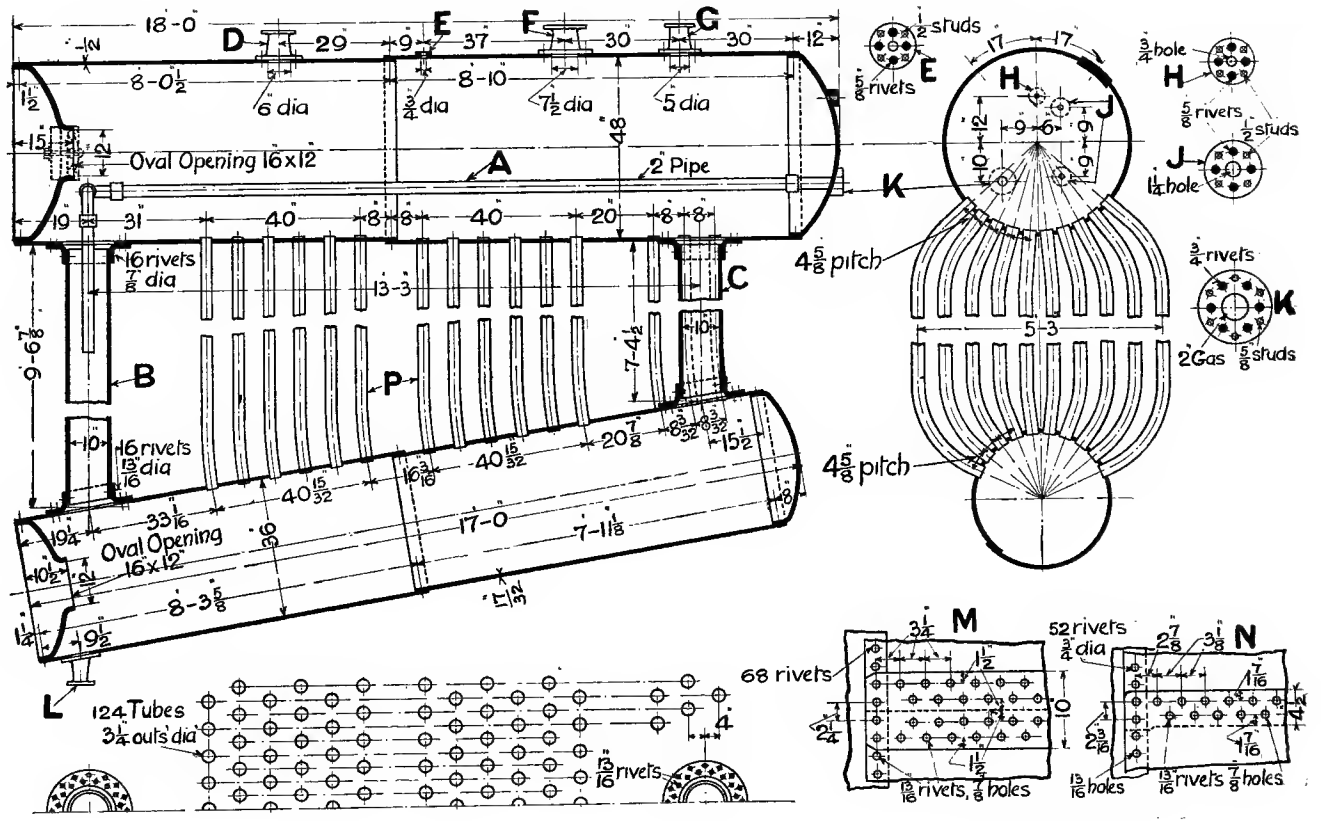
The hot gases from the furnace pass along under the steam drum, coming into contact with the upper portions of the water tubes. When these gases reach the back end of the furnace they descend and return beneath special horizontal baffles (V) fitted between the tubes. After coming into contact with the lower portions of the water tubes the gases finally pass beneath the lower drum to the flue through the swivel damper (W).

Hinged vertical baffles (Z) are placed between the walls of the furnace and the outer tubes so as to direct the gases to the tubes.

REFERENCES

A Feed Pipe.	**C2** Fire Grate.	**R** Cast-iron Supporting Cradle.	**W** Swivel Damper.
A2 Inspection Doors.	**F** Steam Stop Valve Seating.	**S** Cowl.	**X** Steam Drum.
B Downtake.	**L** Blow-off Valve.	**T** Perforated Diaphragm.	**Y** Water Drum.
B2 Soot Doors.	**P** Water Tubes.	**U** Perforated Pipe.	**Z** Vertical Baffles.
C Uptake.	**Q** Suspension Girder.	**V** Horizontal Baffles.	

PLATE No. 43


18-0
D
29
E
9
37
F
30
G
30
12
8-0½
6 dia
¾ dia
8-10
7½ dia
5 dia
48
Oval Opening 16x12
A
2 Pipe
19
31
40
8
8
40
20
8
8
16 rivets 7/8 dia
13-3
B
P
C
9-6⅞
7-4½
10
16 rivets 13/16 dia
10
19¼
33 1/16
Oval Opening 16x12
10½
21
8-3⅝
36
40 15/32
16 3/16
40 15/32
20⅞
6 3/32
3 3/32
15½
17-0
7-11⅛
1¼
9½
L
124 Tubes 3¼ outs dia
4
13/16 rivets
½ studs
E
rivets
H
17
17
9
6
9
10
K
4⅝ pitch
5-3
4⅝ pitch
¾ hole
H
⅝ rivets
½ studs
J
1¼ hole
¾ rivets
K
2 Gas
⅝ studs
M
3¼
1½
68 rivets
10
2¼
1½
13/16 rivets, 7/8 holes
52 rivets ¾ dia
2⅞
3⅜
N
1 7/16
4
2 3/16
1 7/16
13/16 holes
13/16 rivets 7/8 holes

"SUCKLING" WATER-TUBE BOILER

Some details of a "Suckling" Water-tube Boiler are illustrated on this plate. A general description of the boiler and its furnace are given on the previous plate. It may further be noted that the water tubes (P), of which there are 124, are "expanded" into both drums, and that their ends project about $\frac{3}{8}''$ into each drum. All these tubes are curved at their ends so that they enter the drums radially. This curving of the tubes also provides for expansion and contraction in the same way as an expansion loop in a steam pipe.

The seatings on the steam drum are for various boiler fittings as follows: (D) $2\frac{1}{2}''$ dead weight safety valve. (E) Tube cleaning valve, (F) 5″ steam stop valve. (G) 3″ spring loaded lock-up safety valve. (H) Syphon connection. (J) Water gauges. (K) Combined check-feed and stop-cock. The seating (L) on the lower drum is for a blow-off pipe. The seatings (D, F, G, and L) are of cast steel, the remainder being wrought iron.

At the back end of each drum there is a manhole in the end plate. These manholes are fitted with mild steel covers and cross-bars, the covers being inside the drum and the cross-bars outside, the fixing being by means of bolts.

View (M) shows the riveting of the joints in the upper drum, and view (N) that of the lower drum.

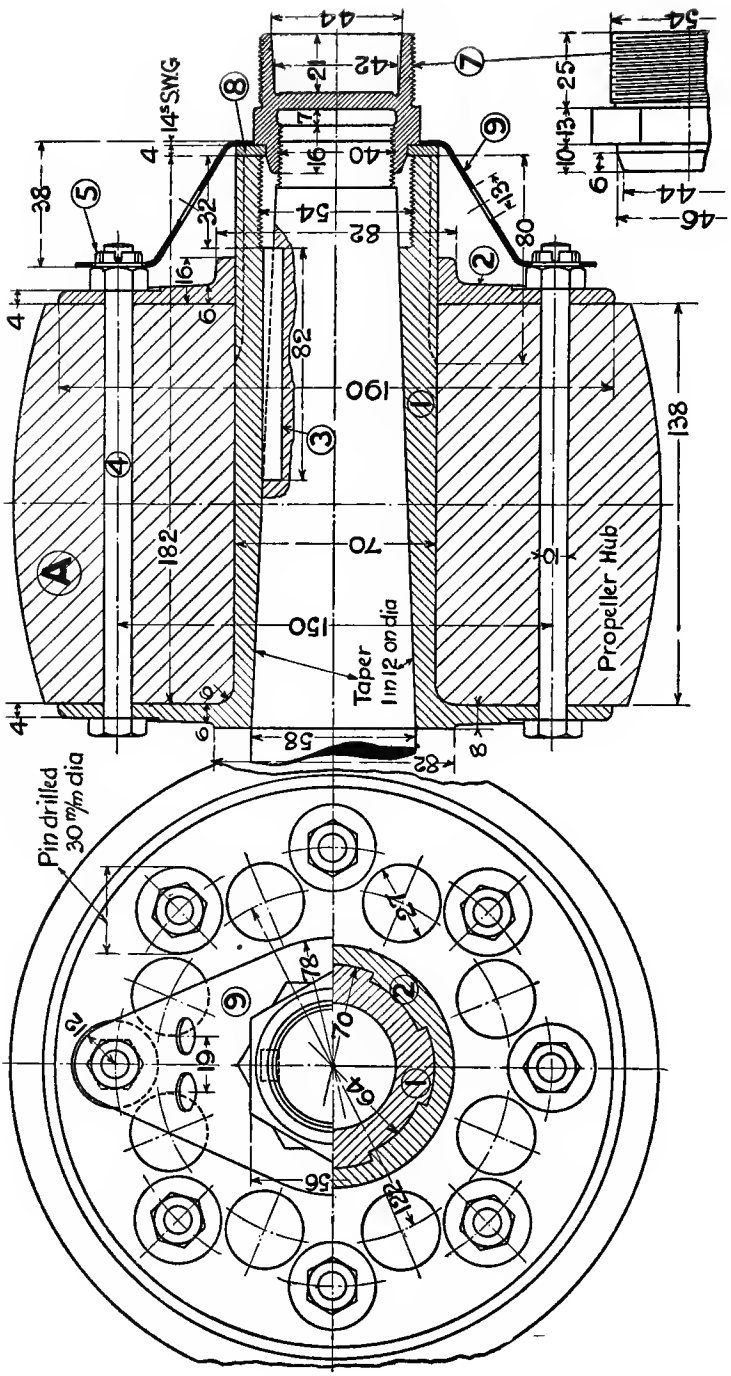
EXAMPLE 73.—Make a working drawing of a manhole cover complete for the upper drum. The cover is $17\frac{7}{8}'' \times 13\frac{7}{8}'' \times \frac{7}{8}''$ thick. There are two cross-bars $6\frac{3}{4}''$ apart centre to centre. The cross-bars are $2\frac{3}{8}''$ thick $\times$ $1\frac{7}{16}''$ wide, swelled out at the centre to 3″ diameter to take a bolt $1\frac{1}{4}''$ diameter. The greatest length of the cross-bar is $13\frac{1}{8}''$.

EXAMPLE 74.—Make a drawing of the complete boiler (without furnace). Seatings for boiler mountings need not be shown, but full particulars of the boiler joints must be given.

SECTION V

DETAILS OF AEROPLANE ENGINES AND MOTOR VEHICLES

PLATE No. 44


Pin drilled 30 m/m dia
Taper 1 in 12 on dia
Propeller Hub
14s SWG
A

PROPELLER HUB FOR AEROPLANE

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Sleeve	Steel	1	—
2	Loose End Plate	,,	1	—
3	Key for Sleeve	,,	1	12 × 6 × 82
4	Hex. Hd. Bolts (heads 6 mm. thick) .	,,	8	10 × 165
5	Castle Nuts for Bolts (tapped 1½ mm. pitch) .	,,	8	Total thickness, 12½"
6	Split Pins for Castle Nuts	Mild Steel	8	3 × 25
7	Nose Nut (external threads 11 per inch, internal 1½ mm. pitch)	,,	1	—
8	Washer for Nose Nut	,,	1	70 mm. dia. 48 mm. hole
9	Locking Plate . . .	,	1	—

The illustration on the opposite page shows the arrangement of the Hub for the Propeller of an Aeroplane.

The central boss of the propeller (marked A) is of wood, and is mounted on a flanged sleeve (1), which fits a tapered seat on the shaft.

This sleeve is fixed to the shaft by means of a key (3). The outer periphery of the sleeve is splined for a length of 80 mm. at the flangeless end to receive the loose end plate (2), which is similarly splined on its inside periphery.

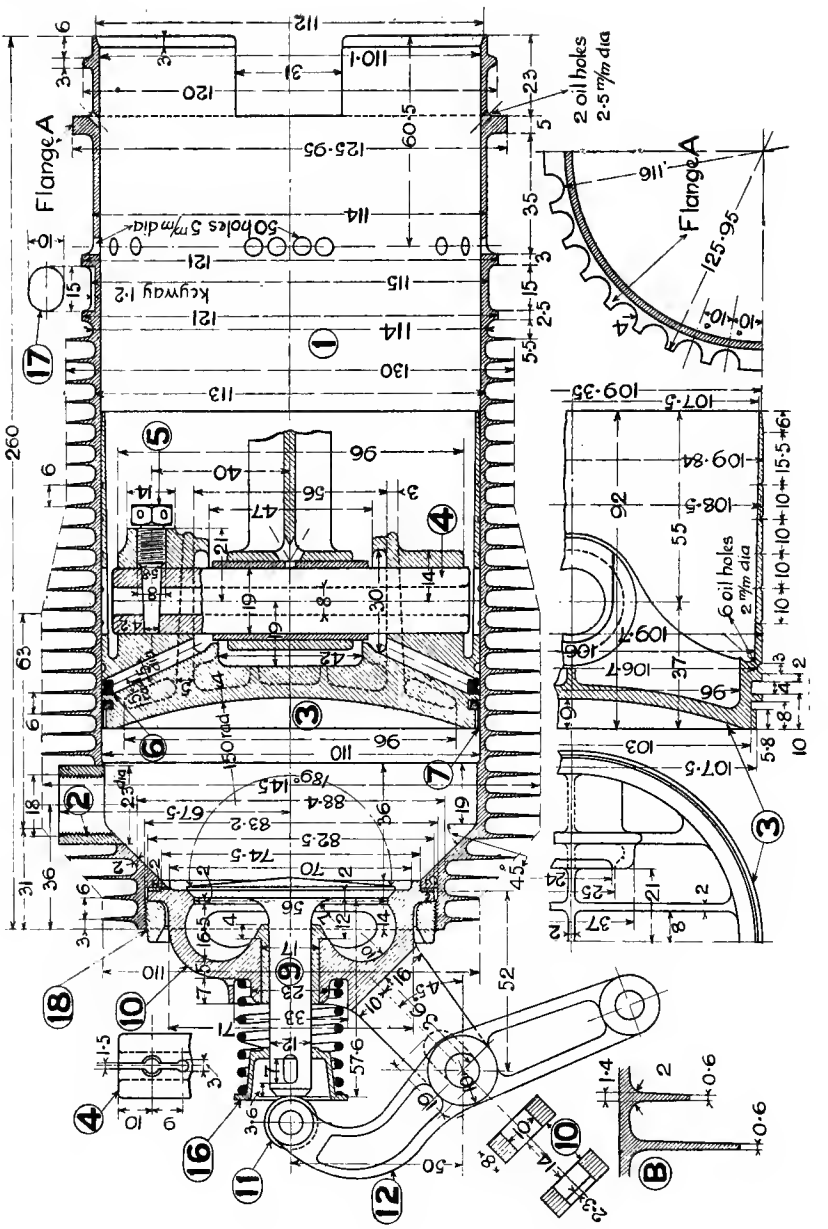
The propeller is clamped firmly to the sleeve by means of the eight bolts (4). Both the flange on the sleeve and the loose end plate are lightened by the drilling of eight holes in each, 27 mm. diameter.

The whole hub is prevented from moving endways on the shaft by the nose nut (7), which is locked by the plate (9). The nose nut is a double-purpose nut. In the position indicated in the illustration, the nut is performing its usual function of holding the hub in place on the shaft. When it is required to replace the propeller, the locking plate (9) is taken off, the nose nut unscrewed, and the washer (8) removed. The nose nut is then reversed, and by its external thread screwed into the end of the sleeve. When the central wall of metal in the nut presses against the end of the shaft, the sleeve of the hub is quickly released from the tapered seat, the nut thus acting as a withdrawal tool.

Example 75.—Make separate detail working drawings of each of the following items : 1, 2, 7, and 9.

Note.—Items 1, 2, and 4 are made of high quality steel, having an ultimate strength of 55 tons □".

PLATE No. 45


Flange A
50 holes 5 m/m dia
Keyway 1·2
2 oil holes 2·5 m/m dia
6 oil holes 2 m/m dia
Flange A
260
112
110·1
120
125·95
114
121
115
130
113
96
40
56
47
42
150 rad
178°
145
88·4
83·2
82·5
74·5
70
67·5
63
36
31
110
71
57·6
52
45°
109·35
107·5
109·84
108·5
106·7
103
92
55
37
25
21
116
125·95
10°
B

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Cylinder	Carbon Steel	9	—
2	Sparking Plug Boss . .	,,	9	—
3	Piston . . .	Cast Iron	9	—
4	Gudgeon Pin	Case Hdnd. Steel	9	100 mm. long
5	Set Screw for Gudeon Pin .	Mild Steel	9	—
6	Piston Ring	Cast Iron	9	—
7	Obturateur	Special Alloy	9	—
8	Locking Ring for Obturateur	Mild Steel	9	—
9	Exhaust Valve . . .	Steel	9	—
10	,, ,, Seat . .	,,	9	—
10A	Exhaust Valve Seat Washer, $82\frac{1}{2}$ dia.	Copper and Asbestos	9	—
11	Exhaust Valve Roller . .	Cast Steel	9	15 mm. dia. 8 mm. thick
12	,, ,, Lever . .	Steel Stamping.	9	—
13	,, ,, Guide . .	Cast Iron	9	184
14	,, ,, Cotter . .	,, Steel	9	7 × 4 × 19
15	,, ,, Spring . .	Spring Steel	9	7 coils 12s B.W.G.
16	,, ,, ,, Cap .	St'l Stamp'g	9	—
17	Key for Cylinder . . .	Key Steel	9	10 × 2·4 × 15
18	Castellated Ring Nut . .	Mild Steel	9	—

The 100 H.P. Monosoupape Gnome Engine is of the rotary type, and has nine cylinders, one of which complete with piston, valve, etc., is shown on the plate facing this page.

The crank case of the engine is made in halves, which are bolted together, and grip the cylinders at their bases, the cylinders being prevented from turning in the crank case by keys (item **17**).

Each cylinder has 50 holes or ports of 5 mm. diameter drilled near the lower end. These ports are uncovered when the piston is at the bottom of its stroke, thus allowing the passage of gas from the crank case to the inside of the cylinder by way of the gaps in flange A.

The cylinder is machined all over, and is made from what is practically a solid forging, the original shape of which is indicated by the dotted lines in the illustration. The rectangular gaps in the lower edges of the cylinder are for connecting rod clearance. An enlarged view of the cylinder fins is shown at B.

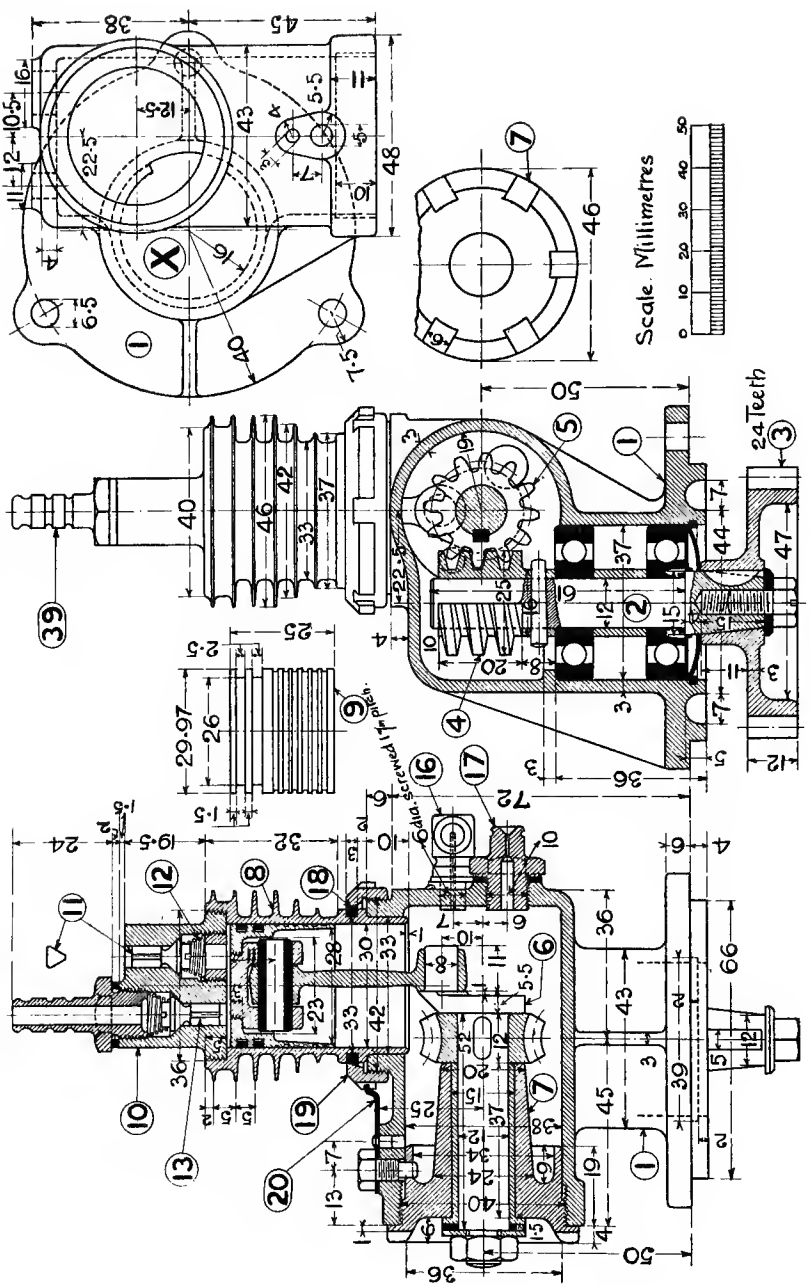
The sparking plug boss is welded in position before the machining of the inside of the cylinder is finished.

The exhaust valve and seating (items **9** and **10**) are made of steel, having an ultimate strength of 90 tons □″. The angle of the seat is 45°. The seating is fixed in the head of the cylinder by means of a castellated nut (**18**), the pitch of the thread on the nut being 1·5 mm. Perfect lubrication in these cylinders is a point of vital importance, and numerous holes and grooves are provided to obtain an efficient distribution of oil to the wearing surfaces. By means of the obturateur (**7**) as an auxiliary to the ordinary piston ring, practically "perfect compression" is obtained.

Example 76.—Separate detail working drawings are to be made of each of the following items: **1**, **3**, and **4**.

Example 77.—Trace the drawing made to Example 76.

PLATE No. 46



AIR PUMP FOR AEROPLANE ENGINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Air Pump Case . . .	Aluminium	1	107
2	,, ,, Spindle. . .	Steel	1	—
3	Gear Wheel. 24 Teeth. 20° Involute	,,	1	Pitch circle dia. 60 mm.
4	Worm. Single Threaded. P.C.D. 21	,,	1	Pitch 6·2832 mm.
5	Worm Wheel. 12 Teeth .	Phosphor Bronze	1	Pitch circle dia. 24 mm.
6	Crank Shaft	Steel	1	—
7	,, ,, Bearing . .	Aluminium	1	108
8	Cylinder	Steel	1	—
9	Piston (6 oil grooves, 1 mm. wide, ½ mm. deep) . .	Cast Iron	1	109
10	Valve Box	Brass	1	110
11	Inlet Valve	Steel	1	—
12	Valve Springs. 7 Coils (conical, 6 to 10 ins. dia.)	Steel Wire	2	26s gauge
13	Discharge Valve . .	Steel	1	—
14	Key for Worm Wheel . .	,,	1	4 × 3½ × 10
15	Bush for Crank Shaft Bearing	Phos. Bronze	1	111
	Relief Valve . . .	Brass	1	112
16	Oil Union	,,	1	113
17	Split Washer. . . .	Steel	1	—
18	Castellated Nut for Case .	Mild Steel	1	—
19	Locking Plate for Castellated Nut for Case	,,	1	·75 mm. thick
21	Securing Screw for Locking Plate	,,	1	5 dia. 10 long
22	Positioning Peg for Locking Plate	,	1	3 dia. 5 long
23	Radial Ball-bearings . .	Hardened Steel	2	—
24	Distance Ferrule for Radial Ball-bearings	Mild Steel	1	16 mm. outs. dia. 13 mm. long
25	Dust Washer for Radial Ball-bearings	Leather	1	37 dia. ·75 thick
26	Dust Washer Retaining Plate	Mild Steel	1	·5 mm. thick
27	Locking Ring for Retaining Plate	Piano Wire	1	—
28	Woodruf Key for Gear Wheel	Steel	1	—
29	Hex. Hd. Set Bolt for Gear Wheel	,	1	6 × 11
30	Washer for Hex. Hd. Set Bolt for Gear Wheel	,,	1	16 dia. 2 thick
31	Hex. Nut for Crank Shaft .	Mild Steel	1	6 mm. thick, tapp'd 8 dia. 1·25 pitch
32	Washer for Crank Shaft Nut	,,	1	20 dia. 1½ thick
33	Thrust Washer for Crank Shaft Nut	Fibre	1	20 dia. 1½ thick
34	Inlet Valve Spring Ferrule (screwed 1 mm. pitch)	Brass	1	12 dia. 5 thick
35	Piston Rings	Phosphor Bronze	2	2½ wide 1½ thick
36	Gudgeon Pin (hole 4 mm. dia.)	Cast Steel	1	7·99 dia. 22 long
37	Connecting Rod . .	Mild Steel	1	40 mm. centres
38	Lug in Piston Head . .	,,	1	—
39	Air Pump Connection . .	Brass	1	114
40	Taper Pin for Worm (taper 1 in 48)	Steel	1	4·4 × 20
41	Washers for Unions . .	Fibre	2	18 dia. 1 thick

For description and examples see following page.

AIR PUMP FOR AEROPLANE ENGINE (*continued*).

Sectional and other conventional views of an Air Pump are given on Plate No. 46, p. 108. This pump is used on the 100 H.P. Gnome Monosoupape Engine, its function being to maintain a constant air pressure in the petrol tank so as to ensure a continuous flow of petrol to the jet. The pump is driven by a gear wheel on the engine casing which gears with the pinion (3) on the spindle (2). This spindle is fitted with a worm (4) driving a worm wheel (5) which is keyed to the crank shaft (6). Through the medium of the crank pin and the connecting rod (37) the reciprocating motion of the piston (9) is obtained.

The downward stroke of the piston causes the opening of the inlet valve (11), which admits air to the cylinder. The upward stroke of the piston closes the inlet valve and drives the air through the valve (13) on its way to the petrol tank, the connector (39) being coupled up to the tank by a flexible pipe. The joint between the connector (39) and the valve box (10) is made by a copper and asbestos washer.

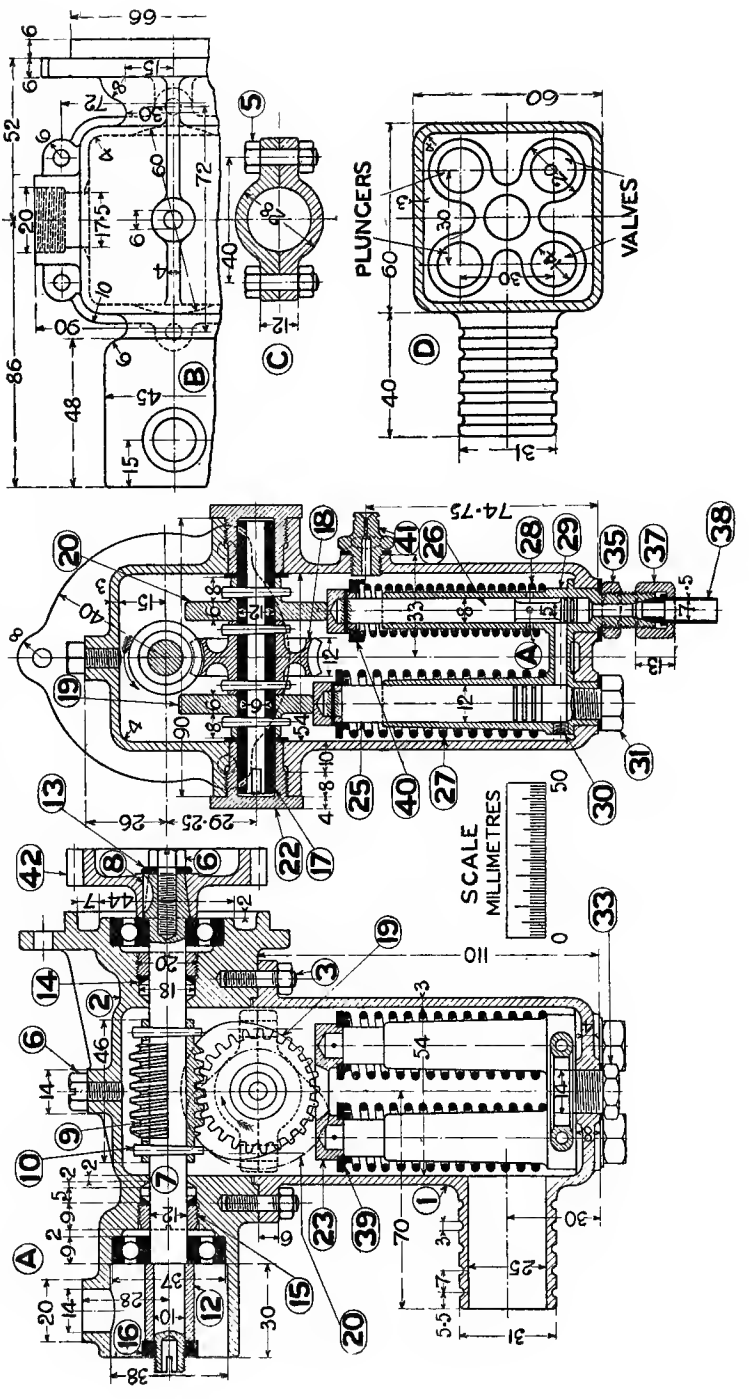
The pump cylinder is fixed to the case by means of a tapered split washer (18) and a castellated nut (19). The nut is slipped over the lower end of the cylinder before the latter is placed in position in the case. The washer (18) (which is in halves) is then placed in the groove in the cylinder body and the nut screwed home. The nut is locked by the plate (20), projections on which fit into the castellations of the nut.

The view marked X is a plan of the case with all other details removed, and occupies its position on the plate on account of exigencies of space. In the detail working drawing of the case that is required to be made this plan must, of course, be placed **underneath and in projection** with one of the elevations.

EXAMPLE 78.—Separate detail working drawings are to be made of each of the following items: **1, 2, 4, 5, 6, 7, 8,** and **9.** Scale **Twice** Full Size. All dimensions are in millimetres.

EXAMPLE 79.—Make a complete general arrangement of the pump, working in inches instead of millimetres. Make all diameters to the nearest $\frac{1}{16}$", and all thicknesses to the nearest $\frac{1}{32}$". Scale **Twice** Full Size.

PLATE No. 47



OIL PUMP FOR AEROPLANE ENGINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Pump Casing (lower part)	Aluminium	1	1081
2	,, ,, (upper part)	,,	1	1082
3	Studs for Fixing (·075 mm. pitch)	Mild Steel	2	5 × 22, screwed 10 and 7
4	Hex. Nuts for Studs	,,	2	4 mm. thick
5	,, Hd. Bolts with Hex. Nuts	,,	4	5 × 21
6	,, ,, Screws	,,	2	6 × 11
7	Worm Spindle (161·5 mm. long)	Steel	1	Largest dia. 15 mm.
8	Woodruf Key	,,	1	14 × 5 × 3·5
9	Worm (single threaded)	,,	1	Pitch line dia. 21 Outs. dia. 24
10	Taper Pins (taper 1 in 48 on dia.)	,,	6	¼ long, largest dia. 3/4"
11	Ball-bearings	Hdnd. Steel	2	—
12	Ferrule for Bearing	Mild Steel	1	Length 25 mm. Outs. dia. 16 mm.
13	Washer	,,	1	Dia. 16 mm. Thickness 2 mm.
14	Gland Washers	Gun Metal	2	3 mm. thick
15	Glands (screwed 1½ mm. pitch)	,,	2	Length 8 mm.
16	Hex. Nut (tapped 1½ mm. pitch)	Mild Steel	1	5 mm. thick
17	Shaft for Worm Wheel and Cams	Steel	1	Length 88 mm.
18	Worm Wheel (25 teeth, 15° involute)	Gun Metal	1	Max. dia. 42·5 mm., length through hub 24
19	Cam for Plungers	Hard Cast Steel	1	—
20	,, Valves	,,	1	—
21	Washers	Fibre	2	20 mm. dia. 1 mm. thick
22	Bearings for Worm-wheel Shaft	Gun Metal	2	—
23	Coupling Link	Hard Cast Steel	2	—
24	Pins for Coupling Link	Mild Steel Wire	4	Length 15 mm. Dia. 14 S.W.G.
25	Plungers (3 grooves 1 mm. wide)	Steel	2	Length 70 mm. Dia. 12 mm.
26	Valves (2 grooves 1 mm. wide)	,,	2	Length 77 mm. Dia. 8 mm.
27	Pluuger Spring (14 coils)	Piano Wire 2·5 mm. dia.	2	Length 88 mm. Outs. dia. 22 mm.
28	Valve ,, (18 coils)	Piano Wire 2 mm. dia.	2	Length 88 mm. Outs. dia. 17 mm.
29	Oil Pump Body	Gun Metal	1	1083
30	Plug (screwed ·75 mm. pitch)	,,	1	Length 4 mm. Dia. 5 mm.
31	Hex. Hd. Plugs (screwed 1·5 mm. pitch)	,,	2	Length 8·5 mm. Dia. 10 mm.
32	Washers for Hex. Hd. Plugs	Fibre	2	Dia. 18 mm. Thickness 1 mm.
33	Hex. Hd. Plug (screwed 1·5 mm. pitch)	Gun Metal	1	Length 10 mm. Dia. 14 mm.
34	Washers for Hex. Hd. Plug	Fibre	1	Dia. 20 mm. Thickness 1 mm.
35	Hex. Nuts for Pump Body (tapped 12 mm. dia. 1·5 mm. pitch)	Gun Metal	2	Across corners 18 mm., thickness 6 mm.
36	Washers for Hex. Nuts for Pump Body	Fibre	2	Dia. 20 mm. Thickness 1 mm.
37	Hex. Union Nut (tapped 12 mm. dia. 1·5 mm. pitch)	Gun Metal	2	18 mm. across corners
38	Union Nipple	Mild Steel	2	—
39	Washer for Plunger Spring	,,	2	—
40	,, ,, Valve Spring	,,	2	—
41	Union for Air Pump	Gun Metal	1	Screwed 10 mm. dia. 1·5 mm. pitch
42	Gear Wheel (24 teeth, 6·2832 pitch)	Steel	1	Exactly same as item 3, Plate 46

For description and examples see following page.

OIL PUMP FOR AEROPLANE ENGINE (*continued*)

Two sectional elevations and two partial plan views of the Oil Pump used with the Gnome Monosoupape Engine are given on the plate on page 112. The view B is a plan of the upper part of the casing, and the view D a sectional plan of the lower part of the casing with the pump body, etc., removed. These plans are placed in their respective positions owing to exigencies of space. They should both be projected under view A. The right-hand elevation is a conventional section, and includes a section through the centre of the worm wheel and also through the centre of a plunger and valve. View C is a section showing part of the joint between items 1 and 2.

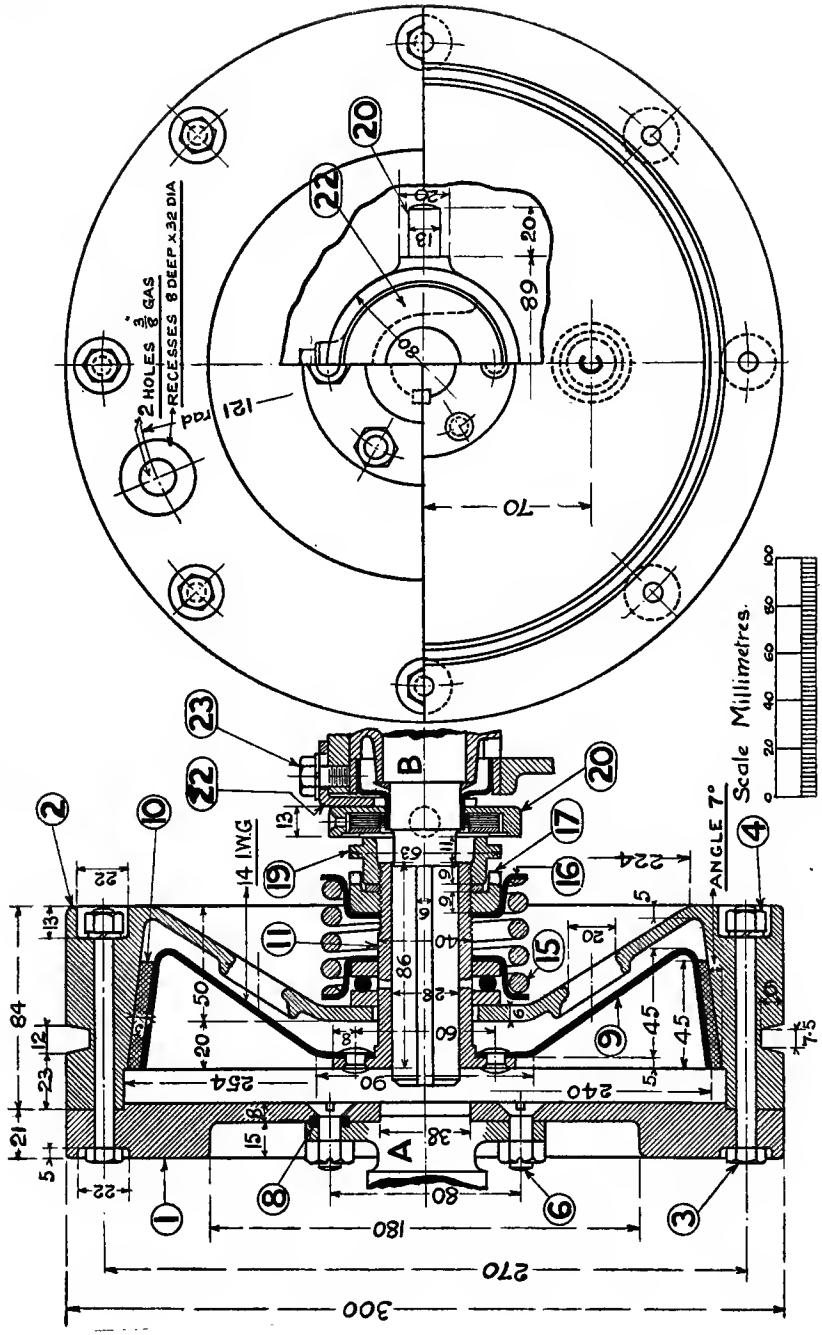
The pump is driven by a gear wheel on the revolving engine casing which meshes with the gear wheel (42) on the worm shaft (7). On the worm wheel shaft (17) are two cams (19) and (20). Cam (19) operates the two plungers (25) and cam (20) the two valves (26). The upward stroke of the plungers draws the oil from the pump casing (1) to the pump body (29) through the four holes marked A, these holes being 3 mm. diameter.

The down stroke of the plunger forces the oil through the union and nipple to the pipes which are connected by similar unions to those parts of the engine requiring lubrication. The pump requires no adjustment, the quantity of oil delivered being directly proportional to the speed of the engine.

EXAMPLE 80.—Make separate detail working drawings of each of the following items: **1**, **2**, **9**, and **18**.

EXAMPLE 81.—Make a complete general arrangement of the pump, working in inches instead of millimetres. Make all diameters to the nearest $\frac{1}{16}''$ and all thicknesses to the nearest $\frac{1}{32}''$.

PLATE No. 48


2 HOLES ⅜" GAS
RECESSES 8 DEEP x 32 DIA
121 rad
70
89
20
22
23
B
C
A
14 I.W.G
ANGLE 7°
Scale Millimetres
0 20 40 60 80 100
300
270
180
254
240
84
50
86
90
80
38
63
40
60
224
45
45
7.5

MOTOR CAR CLUTCH

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Fly-wheel Plate . . .	Cast Iron	1	3513
2	,, Rim and Clutch Cover	,,	1	3514
3	Hex. Hd. Bolts . . .	Mild Steel	8	8 × 100
4	,, Nuts	,,	8	8 mm.
5	Grover Spring Washers . .	Spring Steel	8	8 mm.
6	C't's'k Hd. Bolts for Fly-wheel for Plate	Nickel Steel	6	10 × 26 over-all
7	Hex. Nuts	,,	6	10
8	Driving Washers . . .	,,	3	18 mm. dia. 4 mm. thick
9	Clutch Cone	Mild Steel Pressing	1	—
10	,, ,, Facing . .	Leather		—
11	,, ,, Centre (screwed 1⅛ mm. pitch)	Case Hdnd. Steel	1 1	—
12	Rivets	Mild Steel		8 mm. dia.
13	Ball Thrust Washers . .	Hdnd. Steel	6	—
14	Balls for Ball Thrust Washers	—	2	—
15	Clutch Spring (103 mm. long free, 47 mm. long in position)	Spring Steel	— 1	4 coils 1s I.W.G. 3¼" mean dia.
16	Clutch Spring Caps . .	Mild Steel Pressing	2	15s I.W.G.
17	,, ,, Adjusting Nut	Case Hdnd. Steel	1	—
18	,, ,, ,, ,, Washer	Mild Steel Pressing	1	50 dia. outs. \ 3 40 dia. ins. / th'k
19	Clutch Spring Lock Nut .	Case Hdnd. Steel	1	—
20	,, ,, Withdraw Ring	Malleable Cast Iron	1	3515
21	Thrust Washers . . .	Phosphor Bronze and Steel	7	—
22	Distance Piece . . .	Mild Steel Pressing	1	8s I.W.G.
23	Hex. Hd. Screw . . .	Mild Steel	1	8 × 15
24	Thackray Spring Washer .	Spring Steel	1	8
25	Rivets (leather facing to coue) .	Copper	24	4 × 10
26	,, ,, ,, ,,	,,	6	8 × 10

A general arrangement of the Clutch of a well-known Motor Car is illustrated on the plate facing this page. The clutch is foot-controlled, the action being as follows :—

Pressure on the clutch pedal forces the trunnion bracket (20) towards the left, forcing with it the clutch centre sleeve (11), and consequently the clutch cone (9), thus disengaging the clutch. When the pressure on the pedal is removed, the spring (15) causes the clutch to re-engage by forcing the cone, etc., to their driving positions.

The fly-wheel, a part of which provides the conical surface for the clutch is made in separate parts (1 and 2), so that, when required, the engine or the gear-box may be detached from the complete unit quite independently. This may be accomplished by simply removing the bolts (3).

A is the engine shaft, and B is the stem wheel shaft in the gear-box. The remaining portion of this shaft is shown on the next Plate, No. 49. The holes in the clutch cover (marked C) are to admit of oiling. The two holes in the fly-wheel plate (tapped $\frac{3}{8}$" gas) are also for oiling purposes, and are fitted with brass plugs.

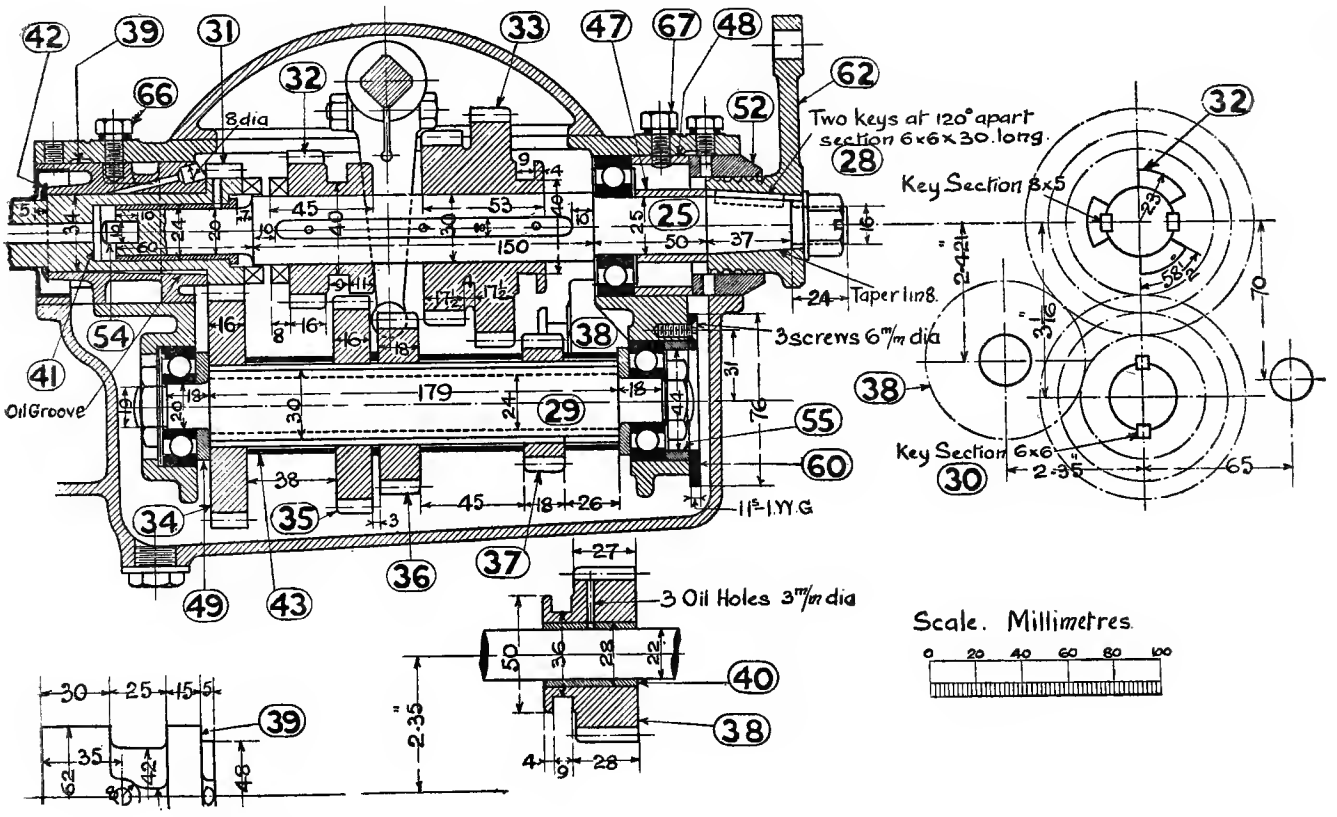
The leather face is riveted to the cone by 24 rivets, 4 mm. diameter, and six rivets, 8 mm. diameter.

On the outside of the clutch centre there are two keyways opposite each other, each 6 mm. wide × 2 mm. deep, extending for a length of 35 mm. from the screwed end. The internal keyways are 6 mm. wide and 3 deep. There are two of these keyways at right angles to the outside ones. The washer (item **18**) has two internal projections to fit the outside keyways.

The adjusting nut (**17**) has four notches to take a pegspanner, each notch being 6 mm. wide × 5 mm. deep. The lock nut (**19**) has four similar notches.

EXAMPLE 82.—Make separate full size detail working drawings of each of the following items: **1, 2, 9, 11,** and **20.**

PLATE No. 49


Two keys at 120° apart section 6×6×30 long.
Key Section 8×5
Key Section 6×6
3 screws 6m/m dia
Taper 1 in 8.
Oil Groove
3 Oil Holes 3m/m dia
11½ I.Y.G
Scale. Millimetres
0 20 40 60 80 100

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
25	Main Shaft . . .	Case Hdnd. Steel	1	1¼" black bar 12⅝" long
26	Feather Key for Main Shaft .	Key Steel	2	8 × 5 × 130
27	Rivets for Feather Key for Main Shaft	Mild Steel	3	3 mm. dia. 40 long
28	Feather Keys . .	,,	2	6 × 6 × 30
29	Lay Shaft	,,	1	1¼" black bar 9⅝" long
30	Feather Keys . . .	,,	2	6 × 6 × 178
31	Stem Wheel and Shaft . .	Case Hdnd. Steel	1	17 teeth 8s pitch
32	3rd and 4th Speed Wheel	,,	1	21 teeth 8s pitch
33	1st and 2nd ,, ,,	,	1	26 and 32 teeth 8s pitch
34	Constant Wheel on Lay Shaft	,,	1	32 teeth
35	3rd Speed ,, ,, ,, ,,	,,	1	28 teeth
36	2nd ,, ,, ,, ,, ,,	,,	1	23 teeth
37	1st ,, ,, ,, ,, ,,	,,	1	17 teeth
38	Reverse Wheel .	,,	1	22 teeth
39	Stem Wheel Bearing	Gun Metal	1	3516
40	Bush for Reverse Wheel .	Phosphor Bronze	1	3517
41	Thrust Washer for Main Shaft	Case Hdnd. Steel	1	5 mm. thick
42	Stem Wheel Oil Ring .	Mild Steel	1	44 mm. dia. 3 thick
43	Distance Ferrule for Lay Shaft	Steel Tube	1	44 outs. dia. \ 38 mm. 35½ ius. dia. / long
44	, ,, ,, ,, ,,	Steel Pressing	1	44 outs. dia. \ 3 mm. 35½ ins. dia. / thick
45	,, ,, ,, ,, ,,	Steel Tube	1	44 outs. dia. \ 45 mm. 35½ ins. dia. / long
46	,, ,, ,, ,, ,,	,,	1	44 outs. dia. \ 26 mm. 35½ ins. dia. / long

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
47	Distance Ferrule for Main Shaft	Steel Tube	1	1¼" outs. dia. 31 mm. long, 11s I.W.G.
48	,, ,, ,, ,, ,,	,,	1	2$\frac{5}{16}$" outs. dia. 25 m. long, 8s I.W.G.
49	Guard Washers for Lay Shaft Bearings	Steel Pressing	2	43 mm. dia. 5 mm. thick
50	Ball-bearings for Lay Shaft .	—	2	—
51	,, ,, ,, Main Shaft	—	1	—
52	Oil Retaining Collar for Main Shaft	Mild Steel	1	62 outs. dia. \ 32 mm. 42·5 ins. dia. / long
53	Stem Wheel Bush . .	Phosphor Bronze	1	3518
54	Button for Main Shaft .	Case Hdnd. Steel	1	17 mm. long
55	Distance Ferrule for Lay Shaft Bearing	Mild Steel Tube	1	2$\frac{1}{16}$" dia. 7s I.W.G.
56	Lay Shaft Nuts (⅝" Whitworth)	Mild Steel	2	19 mm. dia. 1½ mm. pitch 10 mm. thick
57	Guard Washer for Main Shaft Bearing	Mild Steel Pressing	2	51 mm. dia. 19s I.W.G.
58	Packing Washers .	,,	3	52 mm. dia. 19s I.W.G.
59	Guard Washers for Lay Shaft Bearing	,,	2	43 mm. dia. 19s I.W.G.
60	Fixing Plate for Lay Shaft Bearing	,	1	—
61	C't's'k Hd. Screws	Mild Steel	3	6 dia. 16 lcng
62	Star Wheel . . .		1	Drop forging
63	Nut for Main Shaft .	—	—	—
64	Washer for Main Shaft .	—	—	—
65	Split Pin . . .	—	—	—
66	Hex. Hd. Set Screw .	Mild Steel	1	8 × 20
67	,, ,, ,, ,, .	,,	1	8 × 16
68	,, ,, ,, ,, . .	,,	1	8 × 16
69	Positive Lock Washers	Spring Steel	3	8

For description and examples see following page.

MOTOR CAR GEAR-BOX (*continued*)

The Gear-Box Arrangement for a Motor Car is shown on Plate 49, the clutch for the same car being illustrated on Plate 48.

For the first or lowest speed, wheel **33** is moved along the main shaft **25**, by a forked lever not shown, until the teeth of the larger portion of the wheel are in mesh with the teeth of wheel **29**. The drive is then through **31**, **34**, **29**, and **33**.

For second speed, wheel **33** is moved along until the teeth of the smaller portion of the wheel are in mesh with wheel **36**. The drive is then through **31**, **34**, **36**, and **33**.

For third speed, wheel **32** is brought into mesh with wheel **35**, and the drive is through **31**, **34**, **35**, and **32**.

For the fourth or top speed, wheel **32** is moved along the main shaft, until the dog clutch on its left-hand face engages with a similar clutch on the end of the stem wheel shaft. This gives what is called a direct drive, the power not being transmitted through the lay shaft or its gears.

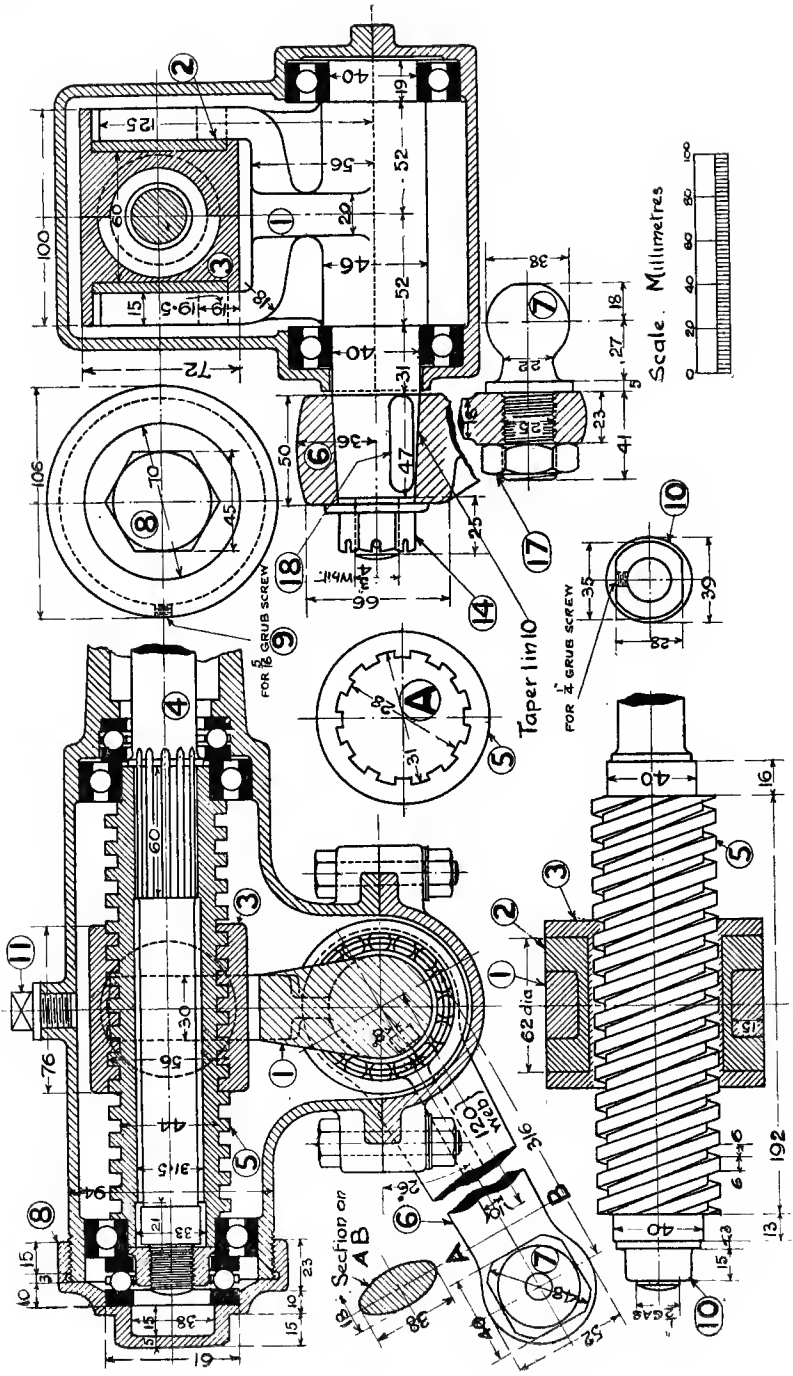
For reversing, wheel **38** is brought into mesh with wheels **29** and **33**. This simply changes the direction of rotation of wheel **33**, and, therefore, of the main shaft.

The power is finally transmitted to the live axle of the car by flexible couplings, one of which is attached to the star wheel **62**.

EXAMPLE 83.—Make detail working drawings of each of the following items: **25**, **29**, **31**, **32**, **33**, **38**, and **39**.

EXAMPLE 84.—Determine the speed of the main shaft for 1st, 2nd, and 3rd speeds, when the engine speed is 1,000 r.p.m.

PLATE No. 50


Scale. Millimetres
Taper 1 in 10
FOR ⅝ GRUB SCREW
FOR ¼ GRUB SCREW
Section on AB
62 dia
192

STEERING GEAR FOR MOTOR OMNIBUS

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Steering Fork . . .	Oil Hdnd. Steel	1	Stamping
2	,, ,, Swivel . .	Case Hdnd. Steel	2	—
3	,, Nut	Phosphor Bronze	1	1816
4	,, Spindle . . .	Oil Hdnd. Steel	1	—
5	,, Worm (triple thrded.)	Case Hdnd. Steel	1	36 mm. pitch
6	,, Lever . .	Oil Tougnd. Steel	1	Stamping
7	,, Ball . .	Case Hdnd. Steel	1	Screwed portion 2 mm. pitch
8	Thrust Cap for Steering Box .	Mild Steel Stamping	1	Screwed portion 11 thds. per inch
9	Grub Screw for Locking Cap .	Mild Steel	1	$\frac{5}{16}$" dia. $\frac{5}{16}$" long
10	Nut for Steering Spindle	,,	1	Screwed $\frac{1}{2}$" gas
11	$\frac{3}{8}$" Gas Plug	,,	1	Total length 28 mm.
12	Radial Ball-bearings . .	Hdnd. Steel	4	40 mm.
13	Ball Thrust Washers . .	,,	2 sets	—
14	Castle Nut for Steering Fork .	Mild Steel	1	$\frac{3}{8}$" standard
15	Washer for Castle Nut for Steering Fork	,,	1	$\frac{3}{4}$" standard
16	Split Pin . . .	,,	1	$\frac{1}{8}$" × 2"
17	Hex. Nut for Steering Ball .	,,	1	14 mm. thick
18	Key for Steering Lever	Key Steel	1	12 × 8 × 44
19	Grub Screw for Item **10**. .	Mild Steel	1	$\frac{5}{16}$" dia. $\frac{3}{8}$" long

The Steering Gear of a Motor Omnibus is illustrated on the plate facing this page. The box containing the gear (only a portion of the box is indicated in the illustration) is fixed in some convenient position to the underframe of the omnibus. The necessary movement of the road wheels is transmitted from the driver's control wheel through the steering spindle (**4**) by the agency of the worm (**5**), the nut (**3**), the forked lever (1), and the ball (**7**), the latter engaging in the slot of a special link which controls the swivel motion of the road wheels. This link is not shown.

The worm being triple threaded the steering is very sensitive, a slight turning of the control wheel producing a comparatively large movement of the steering ball, and a consequently pronounced movement of the road wheels.

The reliability of the steering gear plays such an important part in assuring the safety of passengers that only the very best materials are used in its construction, and a reference to the "Material" column in the accompanying list will show that all wearing surfaces are specified as being hardened.

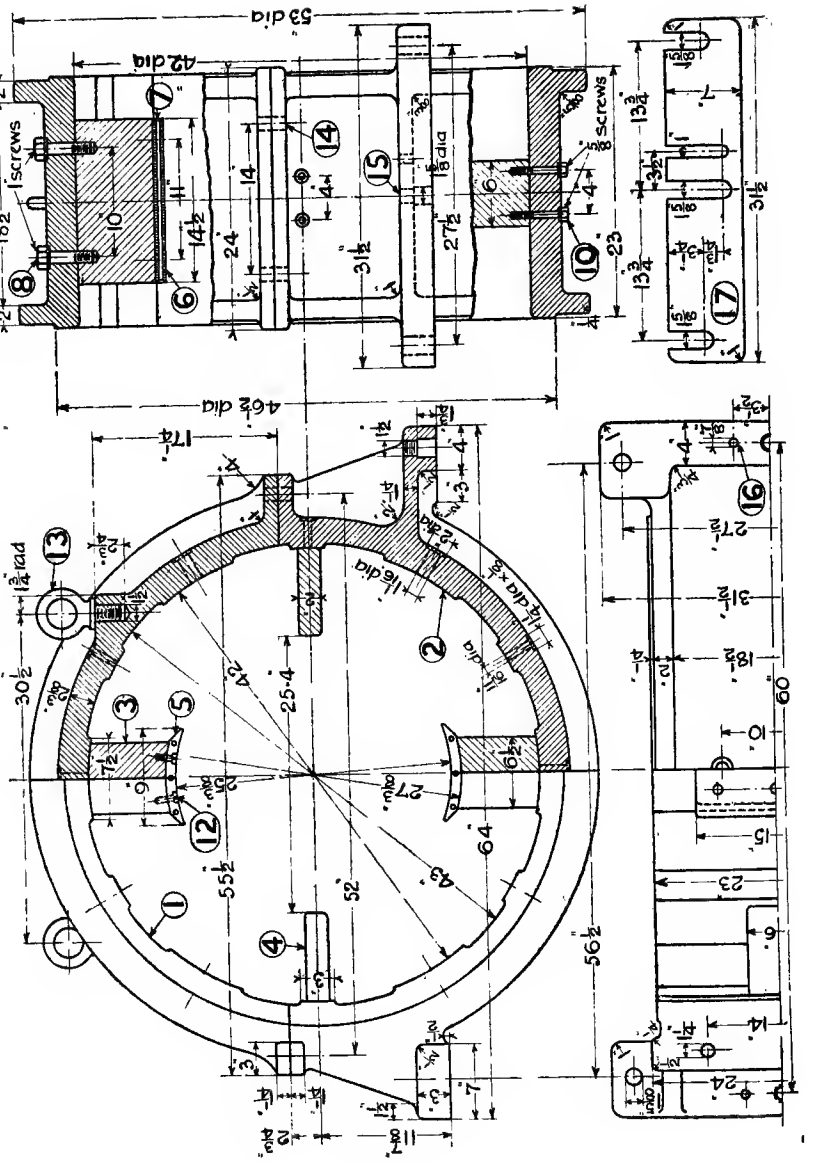
View **A** of item **5** shows the internal splining of the worm, the steering spindle (**4**) being externally splined to receive the worm.

Example 85.—Separate detail working drawings are to be made of each of the following items: **1, 2, 3, 5, 6, 7,** and **8.**

SECTION VI

ELECTRICAL ENGINEERING

PLATE No. 51


53 dia
42 dia
46½ dia
17
30½
55½
25·4
64
56½
60
31½
27½
23
24
screws

FIELD MAGNET FRAME FOR DYNAMO

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Field Magnet Frame (upper half)	Cast Steel	1	2671
2	Field Magnet Frame (lower half)	,,	1	2672
3	Poles	,	6	2673
4	Commutatiug Poles .	,,	6	2674
5	Pole Shoes . . .	Steel	6	—
6	Stampings for Pole Shoes .	Stampings Steel	1440	—
7	Rivets	,,	18	$\frac{3}{8}$″ × 15½″
8	Hex. Hd. Set Bolts (fixing poles)	Mild Steel	12	1″ × 5″
9	Positive Lock Washers (fixing poles)	Spring Steel	12	1″
10	Hex. Hd. Set Bolts (fixing commutating poles)	Mild Steel	12	$\frac{5}{8}$″ × 4½″
11	Positive Lock Washers . .	Spring Steel	12	$\frac{5}{8}$″
12	Cheese Hd. Screws (fixing pole shoes)	Mild Steel	36	½″ × 1½″
13	Eye Bolts	,,	2	1½″ screwed
14	Hex. Hd. Bolts and Nuts (fixing item 1 to item 2)	,,	4	1¼″ × 4″
15	Hex. Hd. Set Screws . .	,,	2	1¼″ × 4¾″
16	Steady Pins	,,	2	$\frac{7}{8}$″ × 4½″
17	Liners for Feet . .	Wro't Iron	12	·02″ thick

Incomplete views of a Field Magnet Frame are given on the plate facing this page. The left half of the end elevation is an outside view, the right half being a section taken on the centre line of the frame. The upper portion of the longitudinal elevation is a section through one of the main poles, the lower portion a partial section through a commutating pole, and the central portion an outside view.

The left-hand half of the semi-plan is a view of the lower half of the frame with the upper half frame removed, whilst the right half of the plan is an inverted view of the lower half of the frame.

The upper and lower castings (items **1** and **2**) forming the field frame are held together by four 1¼″ bolts (item **14**). The main poles (item **3**) are each fixed to the frame by two 1″ set bolts, which are locked by positive lock washers under the heads, the field frame having recesses machined to receive these washers.

The commutating poles (item **4**) are fixed in a similar manner by smaller set bolts and washers.

The pole shoes (item **5**) are built up of thin laminations (item **6**) which are held together by rivets (item **7**), there being three rivets in each shoe. Each shoe is fixed to the pole by six cheese-headed screws.

Between the feet of the magnet frame and the bed-plate of the machine there are a number of very thin liners (six under each foot) (item **17**). As the bearings carrying the armature shaft get worn, the position of the armature

relative to the bore of the field frame alters. To rectify this and keep the armature concentric with the field a sufficient number of these liners are removed from under each foot of the field frame.

The set screws (item 15) are screwed into the tapped holes in the feet of the frame to facilitate the raising of the frame when the removal of the liners is necessary.

This field frame is for a generator of 200 kw. running at 430 r.p.m.

EXAMPLE 86.—Make a working drawing of the field frame (items 1 and 2) without any of the poles. Show the bolts (item 14 only) in position. No other details are to be shown, but all holes for screws, etc., must be clearly indicated.

EXAMPLE 87.—Make a working drawing of a pole shoe complete (item 5).

EXAMPLE 88.—Make a drawing of the field frame, complete, with all the poles and shoes in position. Show all details.

PLATE No. 52

ARMATURE HUB, CORE, AND SHAFT FOR DYNAMO

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Armature Hub	Cast Iron	1	256
2	End Plates	,,	2	257
3	Bolts (screwed $\frac{7}{8}$″ dia. at each end for a length of $1\frac{1}{8}$″)	Mild Steel	3	1″ × $20\frac{1}{4}$″
4	Positive Lock Washers . .	Spring Steel	6	$\frac{7}{8}$″
5	Hex. Nuts . . .	Mild Steel	6	$\frac{7}{8}$″
6	Laminations	Dynamo Steel	14	·04 thick

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
7	Laminations . .	Dynamo Steel	650	·020″ thick
8	Shaft	Mild Steel	1	—
9	Feather Key for Commutator	Key Steel	1	$1\frac{1}{2}$″ × $\frac{5}{8}$″ × $5\frac{7}{8}$″
10	,, ,, ,, Armature Hub	,,	1	$1\frac{1}{2}$″ × $\frac{3}{4}$″ × $4\frac{3}{4}$″
11	,, ,, ,, ,, ,,	,,	1	$1\frac{1}{2}$″ × $\frac{3}{4}$″ × 4″
12	Taper Key for Coupling	,,	1	$1\frac{1}{4}$″ × $\frac{5}{8}$″ × $6\frac{7}{8}$″

Details of the Armature Hub, Core, and Shaft for a Continuous Current Dynamo are given on the plate facing this page.

The core consists of thin laminations (item **7**) threaded on to the hub (item **1**) and clamped between the two end plates (item **2**) by means of the 3 bolts (item **3**). These bolts also act as keys, and are half in the hub and half in the laminations, the driving power of the shaft being thus transmitted to the core through the medium of the bolts. Four ventilating ducts are formed in the core in the manner indicated on page 141.

Thick stampings (item **6**) are used on each side of the ducts and at each end of the armature to prevent buckling or splaying of the thinner lamentations of which the core is built.

It will be noted that one end of the hub is bored out $\frac{1}{16}$″ larger than the other end. This facilitates the assembly of the hub on to the shaft. The hub is driven by means of the two keys **10** and **11**, and is forced on to the shaft by hydraulic pressure.

Example 89.—Make separate detail working drawings of items **1** and **2**.

Example 90.—Design an armature core complete, similar to the one illustrated, but to conform to the following specification :—

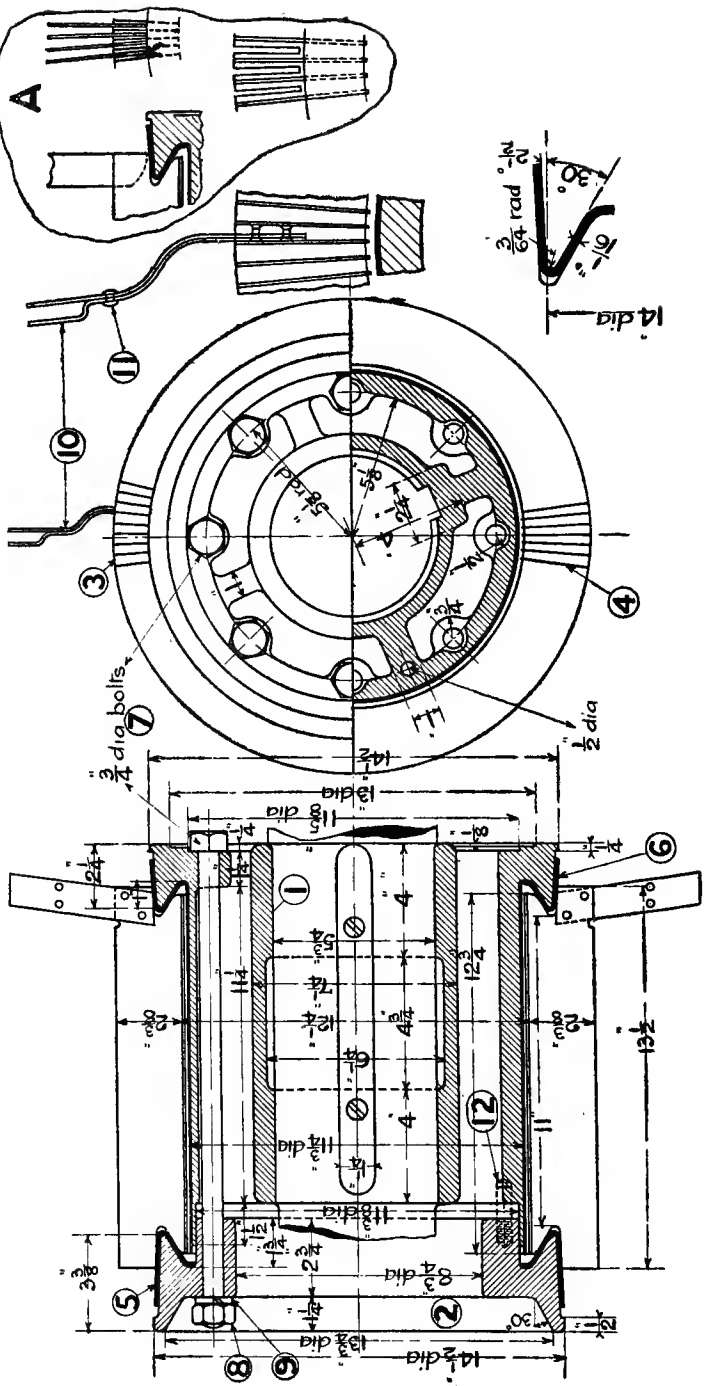
Outside diameter of core, 20″. Inside diameter of core, 11″

Length of core between end plates, 12″ (including three ventilating ducts, each $\frac{3}{8}$″ wide).

Number of slots in core, 80. Shape as per sketch A. Diameter of shaft in hub, $4\frac{3}{4}$″ at one end, $4\frac{11}{16}$″ at other end. Length through hub, $9\frac{1}{2}$″.

Use three $\frac{7}{8}$″ bolts for fixing stampings (reduced to $\frac{3}{4}$″ at ends for nuts and washers).

PLATE No. 53


A
14 dia
3/64 rad
30°
60°
10
11
3
4
7
3/4 dia bolts
1/2 dia
14 1/2
13 dia
11 5/8 dia
6
1
4
12
5
2
8
9
14 1/2 dia
13 3/4 dia
11 1/4 dia
8 3/4 dia
13 1/2

COMMUTATOR FOR CONTINUOUS CURRENT DYNAMO

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Hub	Cast Steel	1	214
2	End Ring	"	1	215
3	Segments	Hard Drawn H.C. Copper	—	—
4	"	Mica	—	—
5	Insulating Ring	"	1	—
6	" "	"	1	—
7	Hex. Hd. Bolts	Mild Steel	8	$\frac{3}{4}'' \times 17''$
8	Hex. Nuts	Mild Steel	8	$\frac{3}{4}''$
9	Positive Spring Lock Washers	Spring Steel	8	$\frac{3}{4}''$
10	Connecting Lugs	Sheet Copper	—	—
11	Rivets for Connecting Lugs	Copper	4 per segment	$\frac{1}{4}''$ dia.
12	Dowel Stud	Mild Steel	1	$\frac{1}{2}'' \times 2''$

The illustration on the plate facing this page shows the general assemby of a Commutator for a large Dynamo.

The commutator consists of about 160 copper segments (3), built up in the form of a ring, each segment being insulated from its neighbours by mica segments, each of which is about $\frac{1}{32}''$ thick. The mica segments, being of uniform thickness throughout, it follows that the copper segments must taper in their thickness, and the actual sizes for the commutator illustrated would be obtained as follows: Outside diameter of commutator (inclusive of machining allowance) $= 17\frac{1}{8}''$. Inside diameter of commutator (no machining inside) $= 12\frac{1}{4}''$.

$\therefore$ Maximum thickness of copper bar $= \frac{17\frac{1}{8} \times \pi}{160} - \frac{1}{32}''$, and minimum thickness $= \frac{12\frac{1}{4} \times \pi}{160} - \frac{1}{32}''$. The bars would, therefore, be made $2\frac{7}{16}''$ wide $\times$ ·305" thick on one edge, and ·209" thick on the other edge. After the segments (copper and mica) are clamped together in ring form, they are bored at the ends to receive the insulating rings (5 and 6), and are then mounted on the hub (1), being well held by the projecting vees on the hub and end ring (2). The commutator is then machined on the outside surface.

In this type the inside is not bored, and the mica segments are arranged to project $\frac{1}{16}''$ inside the edges of the copper segments to increase the leakage surface.

The connections to the armature coils are made by strip copper connections (10), flexibility being obtained by making them to the shape indicated. The connectors are riveted and soldered to the commutator segments, this operation being done, of course, before the segments are assembled together.

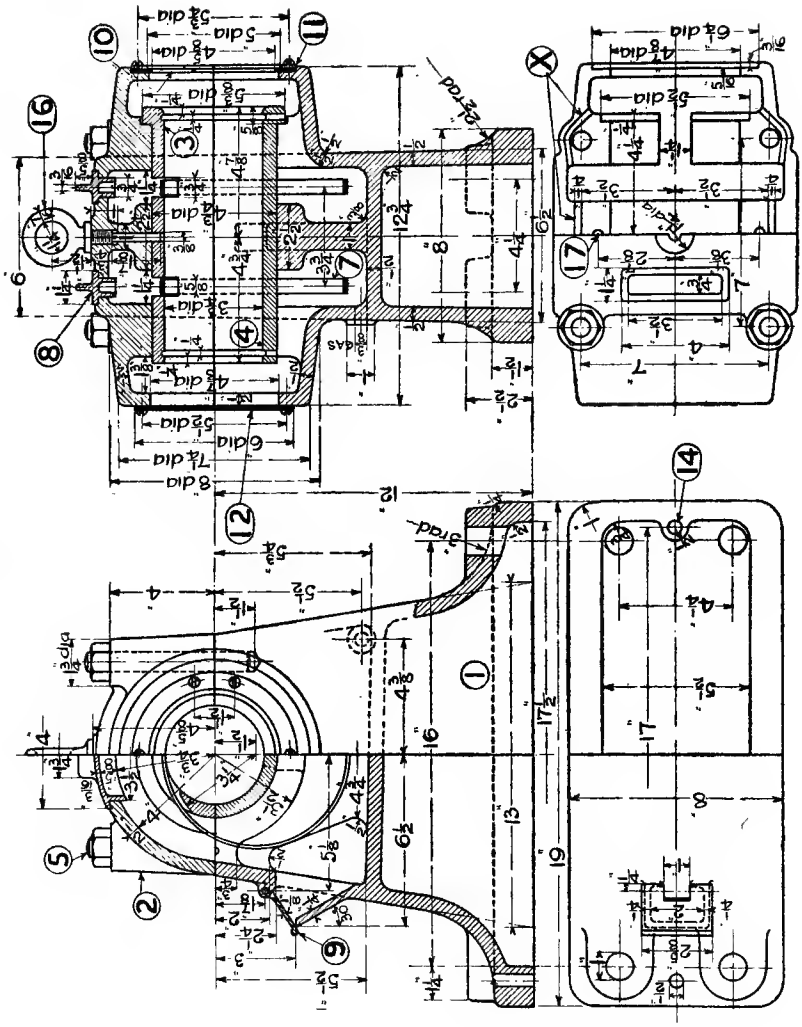
An alternative method of fixing the connectors is shown by the sketches in the space marked A. In this case they are merely soldered or sweated in, rivets not being used. The slots in the segments are milled after the commutator is built up.

Example 91.—Make separate detail working drawings of items 1 and 2.

Example 92.—Design a similar commutator to the following particulars:—

Length of brush surface, 6". Outside diameter, $14\frac{1}{2}''$ Inside diameter, $10\frac{3}{8}''$.
Diameter of shaft in hub, 5" Use eight bolts, $\frac{3}{4}''$ diameter, $10\frac{1}{2}''$ long.

PLATE No. 54



PEDESTAL BEARING FOR DYNAMO

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Bearing Body . . .	Cast Iron	1	413
2	,, ,, Cap . .	,,	1	414
3	,, Bush (upper half) .	Gun Metal	1	415
4	,, ,, (lower half) .	,,	1	416
5	Studs (screwed $1\frac{1}{4}$″ at each end)	Mild Steel	4	$\frac{3}{4}$″ × $6\frac{1}{4}$″
6	Hex. Nuts .	,,	4	$\frac{3}{4}$″
7	Oil Rings	Brass	2	$7\frac{1}{2}$″ outs. dia. $6\frac{3}{4}$″ ins. dia.
8	,, Ring Covers . .	Cast Iron	2	417
9	Oil Well Cover . .	Cast Iron	1	418
10	Wiper Ring	Felt	1	$\frac{1}{8}$″ thick
11	Keep Ring for Wiper .	Wro't Iron	1	$6\frac{1}{4}$″ dia. $\frac{1}{16}$″ thick
12	End Cover	,,	1	$\frac{1}{16}$″ thick
13	Cup Hd. Screws . .	Mild Steel	12	$\frac{3}{16}$″ dia. $\frac{1}{2}$″ long
14	Steady Pins . . .	,,	2	$\frac{1}{2}$″ dia. $2\frac{1}{2}$″ long
15	Split Pin (hinge pin) . .	,,	1	$\frac{3}{16}$″ dia. 3″ long
16	Special Eye-bolt . . .	,,	1	—
17	Dowel Pins	,,	2	$\frac{5}{8}$″ dia. $\frac{1}{2}$″ long

Various views of an Outer Bearing for a Dynamo are given on the accompanying plate.

The lubrication is provided by two brass rings which rest on the shaft and have their lower portions constantly immersed in the bath of oil. As the shaft revolves the rings are carried round with it by friction, and convey a plentiful supply of oil to the shaft and bearing surface. The supply of oil is so liberal with this arrangement that special precautions are taken to prevent surplus oil from getting outside the bearing. Otherwise the oil, by creeping on to the commutator of the machine, would cause much damage. In this instance grooves are turned in the ends of the bush. A slot at the bottom of each groove allows oil to pass back to the oil chamber. Oil ducts are also cut in the surface of the joint, as shown at X, these ducts also leading back to the oil well. A felt wiping ring is also provided (**10**) on which the shaft rubs, and, in addition, an oil-throwing collar is turned on the portion of shaft situated between the bush end and the felt wiper. It will be noted that gaps are cut in the upper half of the bearing bush to allow the rings to rest on the shaft. These gaps should give ample clearance for the rings, as any interference with the movement of the rings has very serious consequences.

To facilitate erection steady pins (**14**) are used for positioning the pedestal on the bed-plate, and dowel pins (**17**) for positioning the cap on the main body.

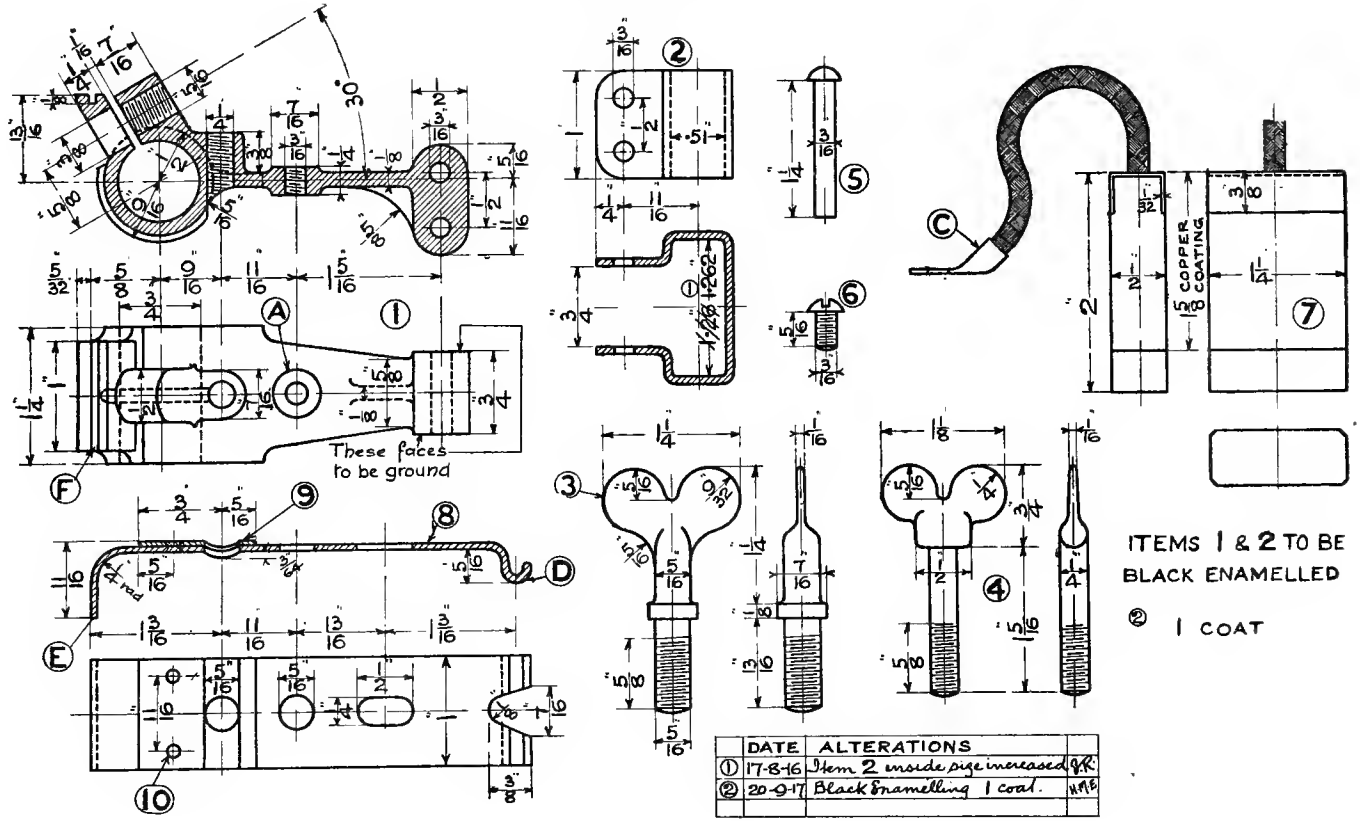
Example 93.—Separate detail working drawings are required to be made of each of the following items: **1**, **2**, **3**, **4**, and **8**.

Note.—The oil ring covers (item **8**) are made an easy fit in the holes, being $\frac{1}{64}$″ clearance all round.

Example 94.—Design a similar bearing to conform to the following dimensions: Diameter of shaft, $4\frac{1}{2}$″. Length of bush, 11″. Rise of pedestal, 15″. Base, 24″ × $9\frac{1}{2}$″. Use $\frac{7}{8}$″ studs for fixing cap, and provide for bolts of $1\frac{1}{8}$″ diameter for fixing pedestal to bed-plate.

Example 95.—Trace the drawing made to Example 93 or 94.

PLATE No. 55



	DATE	ALTERATIONS	
①	17-8-16	Item 2 inside pipe increased	G.K.
②	20-9-17	Black Enamelling 1 coat.	H.M.S.

BRUSH HOLDER FOR CONTINUOUS CURRENT GENERATORS

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Main Casting	Brass	1	74
2	Brush Box . .	Mild Sheet Steel	1	$4\frac{3}{8} \times 1 \times 18$s S.W.G.
3	Clamping Screw . . .	Brass	1	75
4	Tension Adjusting Screw .	,,	1	76
5	Cup Hd. Rivets . .	Wro't Iron	2	$\frac{3}{16}'' \times 1\frac{1}{4}''$
6	,, Screw . . .	Brass	1	$\frac{3}{16}'' \times \frac{5}{16}''$

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
7	Brush with Flexible and Terminal	Carbon	1	$2'' \times 1\frac{1}{4}'' \times \frac{1}{8}''$
8	Spring	Phosphor Bronze	1	·042″ thick
9	,, Top Plate . . .	,,	1	·028″ thick
10	C't's'k Hd. Rivets . .	Copper	2	$\frac{1}{8}''$ dia. $\frac{1}{8}''$ long

The various parts of a Brush Holder are shown in detail on this plate. Such holders are carried on spindles to which they are clamped in the required position by means of the clamping screws (3). The brush itself (7) is an easy sliding fit in the box (2). To ensure good electrical connection between the brush and the holder the brush is provided with a flexible having a terminal (C), which is fixed to the holder on the boss (A) by means of a set screw (6). The pressure of the brush on the commutator is adjustable by means of the adjusting screw (4). This is screwed into the $\frac{1}{4}''$ tapped hole in the holder, and the lower portion of its head, which is spherical in shape, fits into the groove running across the top of the spring. The function of the groove is to lock the adjusting screw at every half turn of the screw.

Incidentally, this plate illustrates a method of recording alterations made on a working drawing, each alteration as it is made being numbered and tabulated.

Example 96.—Make a drawing, full size, showing all the parts assembled together in their working positions, giving an elevation and plan corresponding to the two views of item 1 on the plate. The following order of drawing is suggested :—

(1) Show item **1** in elevation and plan. Leave a clear space of about 3″ all round the elevation.

(2) Show the box (item **2**) fixed to end of item **1** by means of the rivets (item **5**).

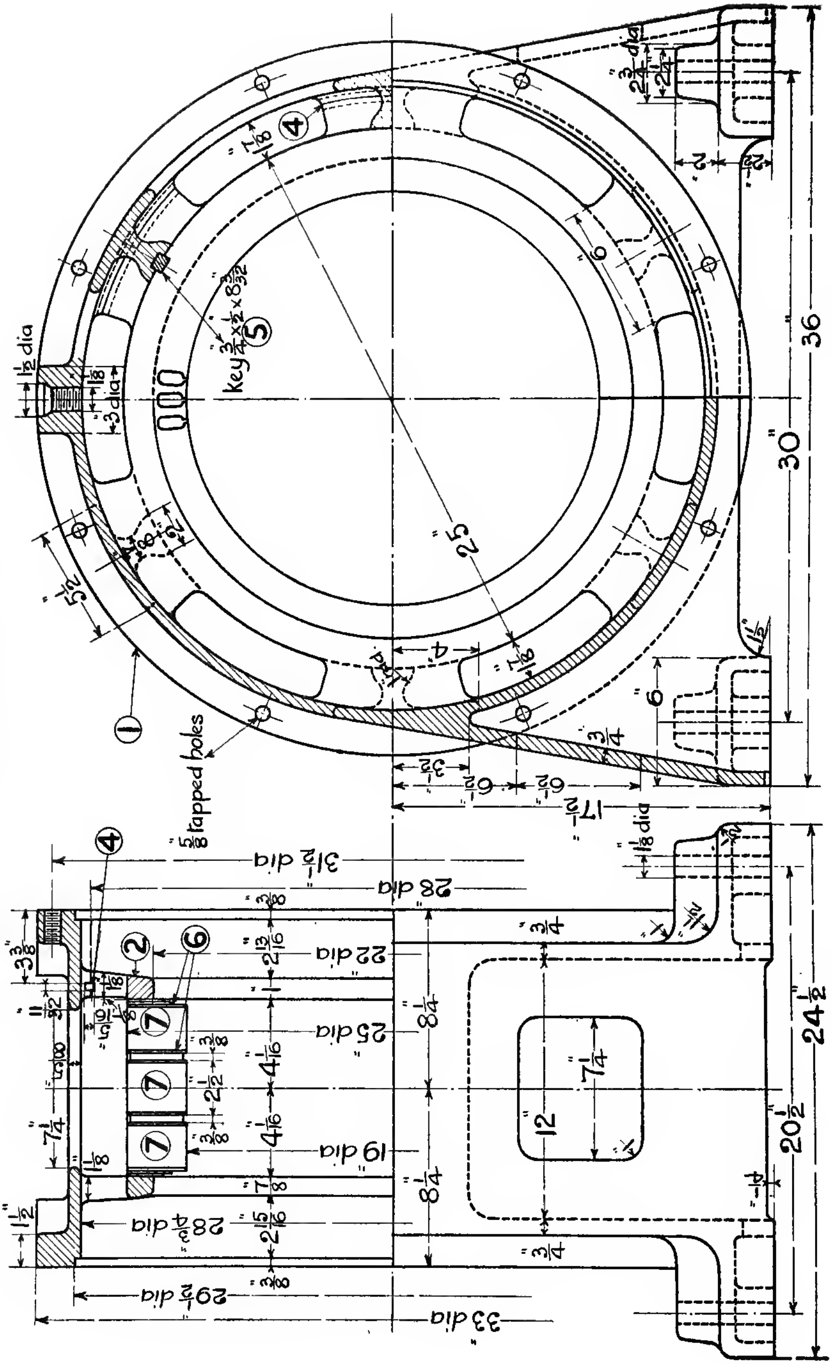
(3) Show the brush (item **7**) in the box with its tip projecting about $\frac{3}{16}''$ through the bottom of the box. Leave out the flexible for the present. *Note.*—The brush is radial to the surface of the commutator.

(4) Show the spring (**8** and **9**) in position with end **D** resting on the brush and end **E** in slot **F** of the holder.

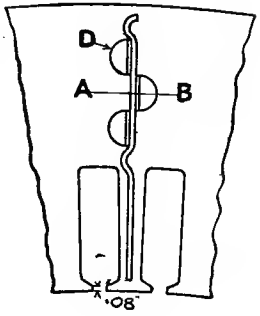
(5) Show the flexible passing through the elongated hole in the spring and with its connector (**C**) screwed down to the boss (**A**) by means of item **6**.

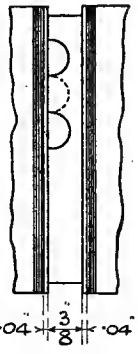
(6) The tension and clamping screws (items **4** and **3**) may now be shown, and the drawing completed.

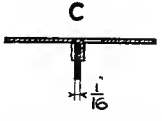
PLATE No. 56


5/8" tapped holes
key 3/4" x 1/2" x 8 3/32"
1 1/2 dia
3" dia
2 3/4" dia
1 1/8" dia
31 1/2" dia
28" dia
22" dia
25" dia
19" dia
28 3/4" dia
29 1/2" dia
33" dia
25"
30"
36"
17 1/2"
6 1/2"
3 1/2"
24 1/2"
20 1/2"
12"
7 1/4"
8 1/4"
4 1/16"
2 1/2"
2 13/16"
2 15/16"
3 3/8"
7 1/4"
1 1/2"
5 1/2"
6"
4"

STATOR SHELL AND CORE FOR INDUCTION MOTOR







Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Stator Shell	Cast Iron	1	219
2	End Ring	,,	1	220
3	Lifting Eye-bolts . .	Wrought Iron	2	$1\frac{1}{8}$″ screwed
4	Locking Keys . .	Steel	6	$\frac{5}{16}$″ × $\frac{5}{16}$″ × $6\frac{3}{4}$″
5	Key for Core	,,	1	$\frac{3}{4}$″ × $\frac{1}{8}$″ × $8\frac{9}{32}$″
6	Laminations	Dynamo Steel	10	·040″ thick
7	,, ...	,,	350	·02″ thick
8	Fingers for Ventilating Ducts	Steel	—	—

The Stator Shell and Core for an Induction Motor are shown on this plate. The core is built up of thin steel laminations (item **7**), there being two ventilating ducts equally spaced along the length of the core. These ducts are formed by fixing fingers to one of the thick laminations which are shown on each side of the ducts. The method of doing this is illustrated by the accompanying sketch. The fingers (item **8**) are made of steel strip, $\frac{3}{8}$″ wide, $\frac{1}{16}$″ thick, and long enough to extend the whole depth of the core, less $\frac{1}{8}$″ at the outside and inside. In one of the thick stampings three semi-circular notches (**D**) are punched, and the metal turned up to grip the finger, as indicated in the sketch. There is one finger on each tooth of the core in each duct. View **C** in accompanying sketch is a section on **AB**.

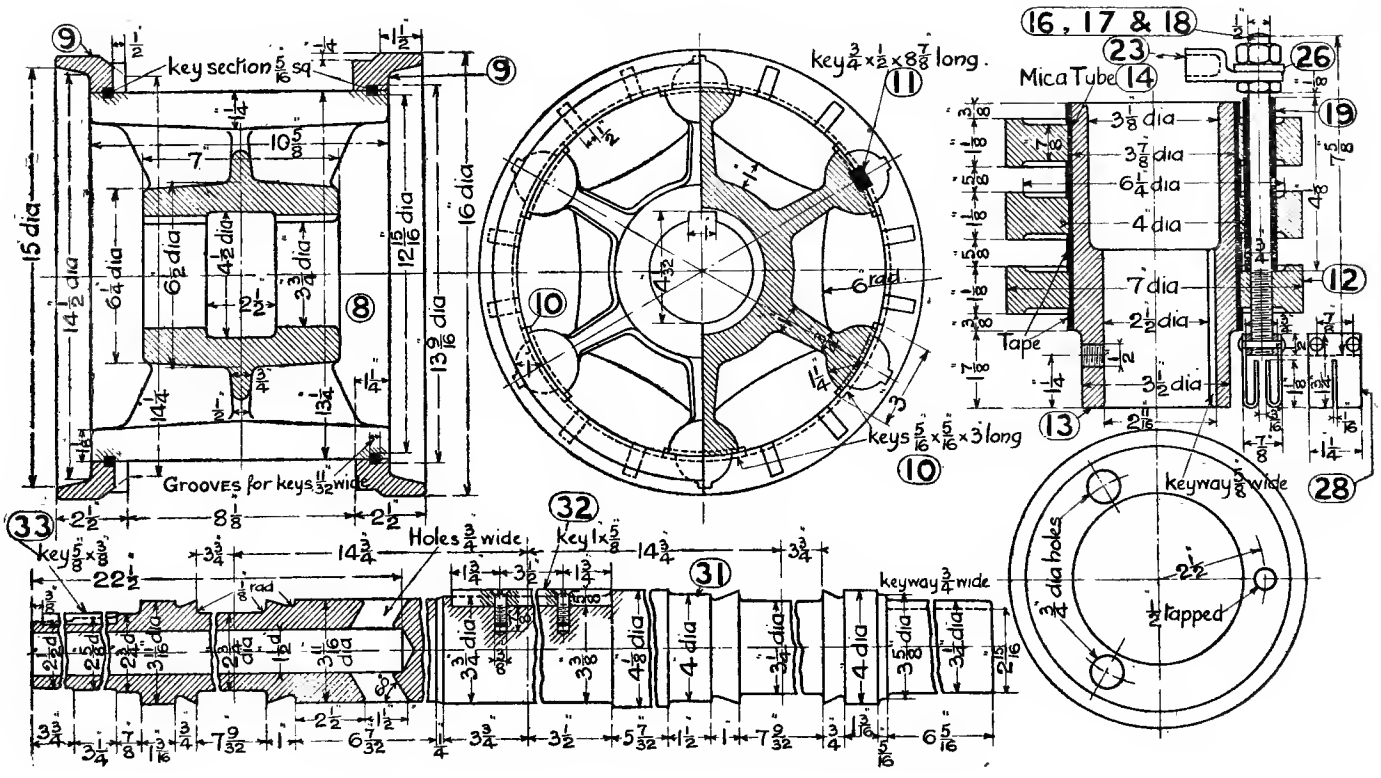
The laminations forming the core are threaded into position on the key (**5**), which ensures the alignment of the slots. When the required number of laminations are in position, the loose end plate (**2**) is pressed into place, and locked by the six keys (**4**), which are inserted into the slots provided. The thick laminations at the ends of the core, and on each side of the ducts, are to prevent the splaying of the thinner laminations. The stator is suitable for a machine of about 70 b.h.p.; at a speed of 725 r.p.m.

Example 97.—Make a detail working drawing of item **1**. Show the two elevations, and add a plan.

Example 98.—Make a general arrangement of the stator complete. No. of slots, 96. The slots are 1·3″ deep × ·45″ wide, the opening being ·14″ wide.

Note.—There are two $1\frac{1}{8}$″ diameter tapped holes in the top of the shell, $13\frac{1}{2}$″ apart, centre to centre. These are for the lifting eye-bolts (item 3).

PLATE No. 57


key section 5/16 sq
15 dia
16 dia
14 1/2 dia
6 1/4 dia
6 1/2 dia
4 1/2 dia
3 3/4 dia
12 15/16 dia
13 9/16 dia
7"
10 5/32"
2 1/2"
14 1/4"
13 1/4"
Grooves for keys 1/32 wide
key 3/4 x 1/2 x 8 7/8 long.
6 rad
keys 5/16 x 5/16 x 3 long
16, 17 & 18
Mica Tube
3 1/8 dia
3 7/8 dia
6 1/4 dia
4 dia
7 dia
2 1/2 dia
3 dia
Tape
keyway 5/16 wide
3/4 dia holes
2 1/2"
1/2" tapped
Key 5/8 x 5/16
Holes 3/4 wide
Key 1 x 5/8
22 1/2"
14 3/4"
keyway 3/4 wide
8 1/8"
2 1/2"
3 3/4 dia
4 1/8 dia
4 dia
3 1/2 dia
3 5/8 dia
2 15/16
6 5/16

ROTOR, SLIP RINGS, AND SHAFT FOR INDUCTION MOTOR

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
8	Rotor Hub	Cast Iron	1	221
9	,, End Rings	,,	2	222
10	Locking Keys	Mild Steel	12	$\frac{5}{16}''$ × $\frac{5}{16}''$ × 3″
11	Driving Key	,,	1	$\frac{3}{4}''$ × $\frac{1}{2}''$ × $8\frac{7}{8}''$
12	Slip Rings	Cast Iron	3	223
13	,, Ring Hub	,,	1	224
14	Insulating Bush	Mica	1	$5\frac{3}{8}''$ long
15	Grub Screw	Mild Steel	1	$\frac{1}{4}''$ × $\frac{5}{8}''$
16	Connecting Stud for Inner Ring	Copper	1	$\frac{1}{2}''$ × $7\frac{5}{8}''$, screwed $1\frac{3}{8}''$ and 2″
17	,, ,, Middle Ring	,	1	$\frac{1}{2}''$ × $7\frac{5}{8}''$, screwed $1\frac{3}{8}''$ and $3\frac{3}{4}''$
18	,, ,, Outer Ring	,,	1	$\frac{1}{2}''$ × $7\frac{5}{8}''$, screwed $1\frac{3}{8}''$ and $5\frac{1}{2}''$
19	Insulating Tube ($\frac{3}{4}''$ dia. $\frac{1}{2}''$ bore)	Micanite	1	$4\frac{1}{2}''$ long
20	,, ,, ,, ,, ,, ,,	,,	1	$2\frac{3}{8}''$ long

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
21	Insulating Tube ($\frac{3}{4}''$ dia. $\frac{1}{2}''$ bore)	Micanite	1	$2\frac{1}{2}''$ long
22	,, ,, ,, ,, ,, ,,	,,	1	4″ long
23	Cable Sockets	Copper	3	—
24	Hex. Nuts	Mild Steel	3	$\frac{1}{2}''$
25	,, Lock Nuts	,,	3	$\frac{1}{2}''$
26	Positive Lock Washers	Steel	3	$\frac{1}{2}''$
27	Contact Bases	Copper	3	$\frac{1}{2}''$ × $\frac{3}{4}''$ × $1\frac{1}{4}''$
28	,, Strips	,,	6	$3\frac{3}{8}''$ × $1\frac{1}{4}''$ × $\frac{1}{16}''$
29	Cup Hd. Rivets	,,	6	$\frac{3}{16}''$ × $1\frac{1}{8}''$
30	Tape for Item 14	Linen	—	—
31	Shaft	Mild Steel	1	—
32	Key for Rotor Hub	,,	1	1″ × $\frac{5}{8}''$ × 7″
33	,, ,, Slip Ring Hub	,,	1	$\frac{5}{8}''$ × $\frac{3}{8}''$ × $6\frac{3}{8}''$
34	C'k's'k Hd. Screws	,,	2	$\frac{3}{8}''$ × $1\frac{1}{4}''$
35	Insulating Tube ($22\frac{1}{2}''$ long)	Paper	1	$1\frac{1}{2}''$ outs. dia. $1\frac{7}{16}''$ ins. dia.

Further details of an Induction Motor are given on this plate. The laminations forming the rotor core (not shown) are threaded on to the rotor hub (item **8**), and fastened by end plates (item **9**) and keys (item **10**) in a similar manner to that adopted in the case of the stator core illustrated on the previous plate. In the case of the rotor, however, the key (item **11**) becomes a driving key, as well as acting as a register for the threading on of the laminations.

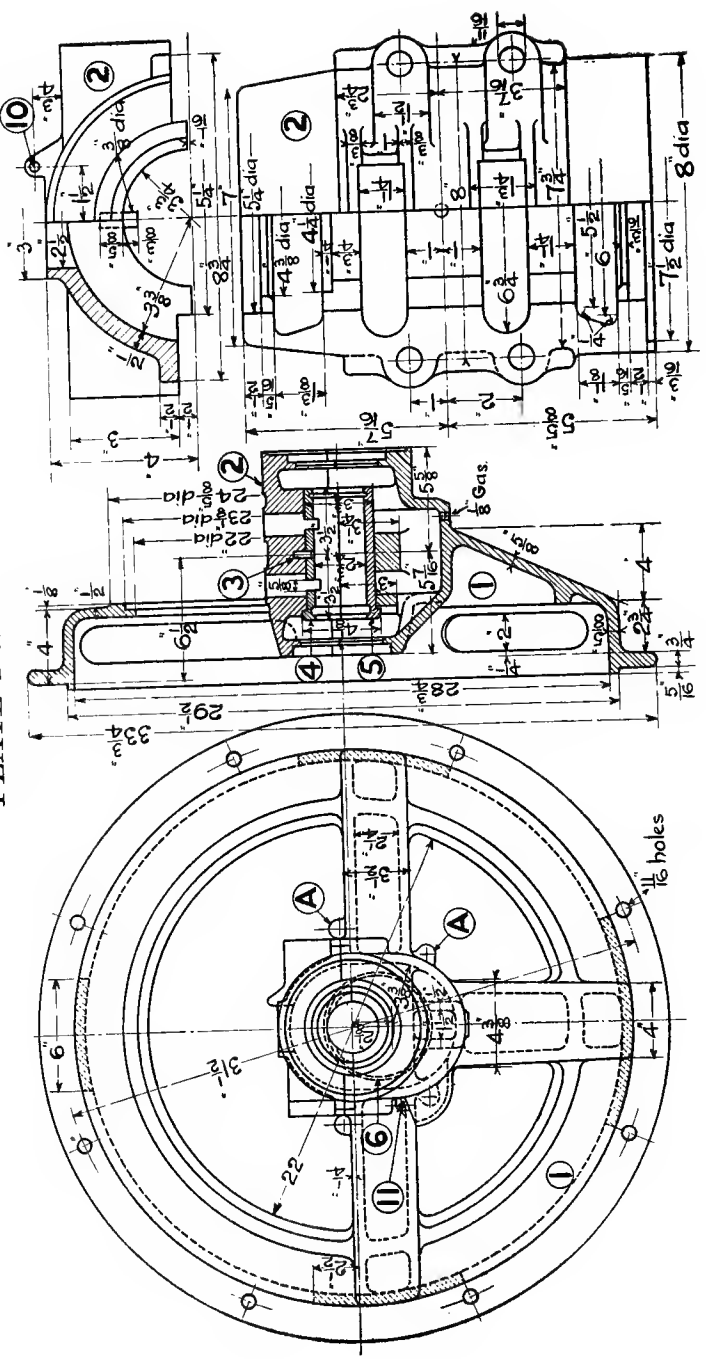
The connections from the rotor windings to the slip rings are taken through the hole in the end of the shaft (item **31**), the shaft being insulated by the paper tube (item **35**).

The three slip rings are exactly alike, but are displaced through 120° relative to one another. The insulating tube (item **19**) is for the connecting stud (item **16**), tubes **20** and **21** are for stud **17**, and tube **22** for stud **18**. The rings are a tight forcing fit on the insulating bush.

Example 99.—Make separate detail working drawings of items **8**, **9**, and **13**.

Example 100.—Make a drawing of the rotor core complete, mounted in position on the shaft. Outside diameter of stampings, 18·9″. Inside diameter, $13\frac{1}{4}''$. Length over laminations, $8\frac{1}{8}''$. This includes one ventilating duct, $\frac{3}{8}''$ wide, and the thick stampings at the ends of the core, and those on each side of the ducts. Number of slots, 120. Slots, 1″ deep × ·3″ wide. Opening in slot, ·1″ wide.

PLATE No. 58



END FRAME AND BEARING FOR ELECTRIC MOTOR

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	End Frame and Bearing Housing	Cast Iron	1	550
2	Bearing Cap	,,	1	551
3	Peg for Cap	Mild Steel	1	$\frac{3}{8}$" dia. 1" long
4	Bearing Bush (upper half)	Gun Metal	1	552
5	,, ,, (lower half)	,,	1	553
6	Oil Rings ($\frac{1}{2}$" wide)	Brass	2	$5\frac{3}{4}$" outs. dia. $5\frac{1}{2}$" ins. dia.
7	Oil Wipers	Felt	2	$5\frac{1}{4}$" dia. $\frac{1}{4}$" thick
8	Keep Rings for Wipers	Wro't Iron	2	$\frac{1}{16}$" thick
9	Cup-headed Screws	Mild Steel	12	$\frac{3}{16}$" × $\frac{5}{8}$"
10	Hinge Pins for Oil-ring Cover	,,	2	$\frac{3}{16}$" × 2"
11	,, ,, Oil-box Cover	,,	1	$\frac{3}{16}$" × $1\frac{3}{8}$"
12	Oil-ring Cover	Cast Iron	2	554
13	Oil-box ,,	,,	1	555

A Bearing formed in the centre of the End Frame is a common feature in most electric motors.

The end frame being spigoted in the field magnet frame and the bearing being bored concentric with the spigot ensures the concentricity of the armature with the field magnet, a point of vital importance.

The illustration on the opposite page shows such an end frame and bearing. As shown, the end frame is of the ventilated type. The motor may be totally enclosed by fixing thin sheet-iron covers over the openings in the end frame, the lugs (marked A) being provided for this purpose. Lubrication is of the ring type. The cap is fixed to the housing by four $\frac{5}{8}$" hexagonal headed set bolts 4" long. The bearing bush is in halves, and is prevented from turning with the shaft by the peg in the cap (3).

Felt oil wipers are provided, as in the case of the bearing shown on Plate No. 54, but in this instance there is a wiper (7) at each end of the bearing. These wipers are in halves, split across the horizontal centre, and are fixed in position by a keep ring (8), (also in halves) and cup-headed screws (9), the latter being equally spaced on circles $4\frac{13}{16}$" diameter. There are six screws per wiper.

The end frame is fixed to the field frame by eight $\frac{5}{8}$" set bolts $1\frac{3}{4}$" long.

The two horizontal arms connecting the bearing housing with the end frame are similar in general shape to the vertical arm.

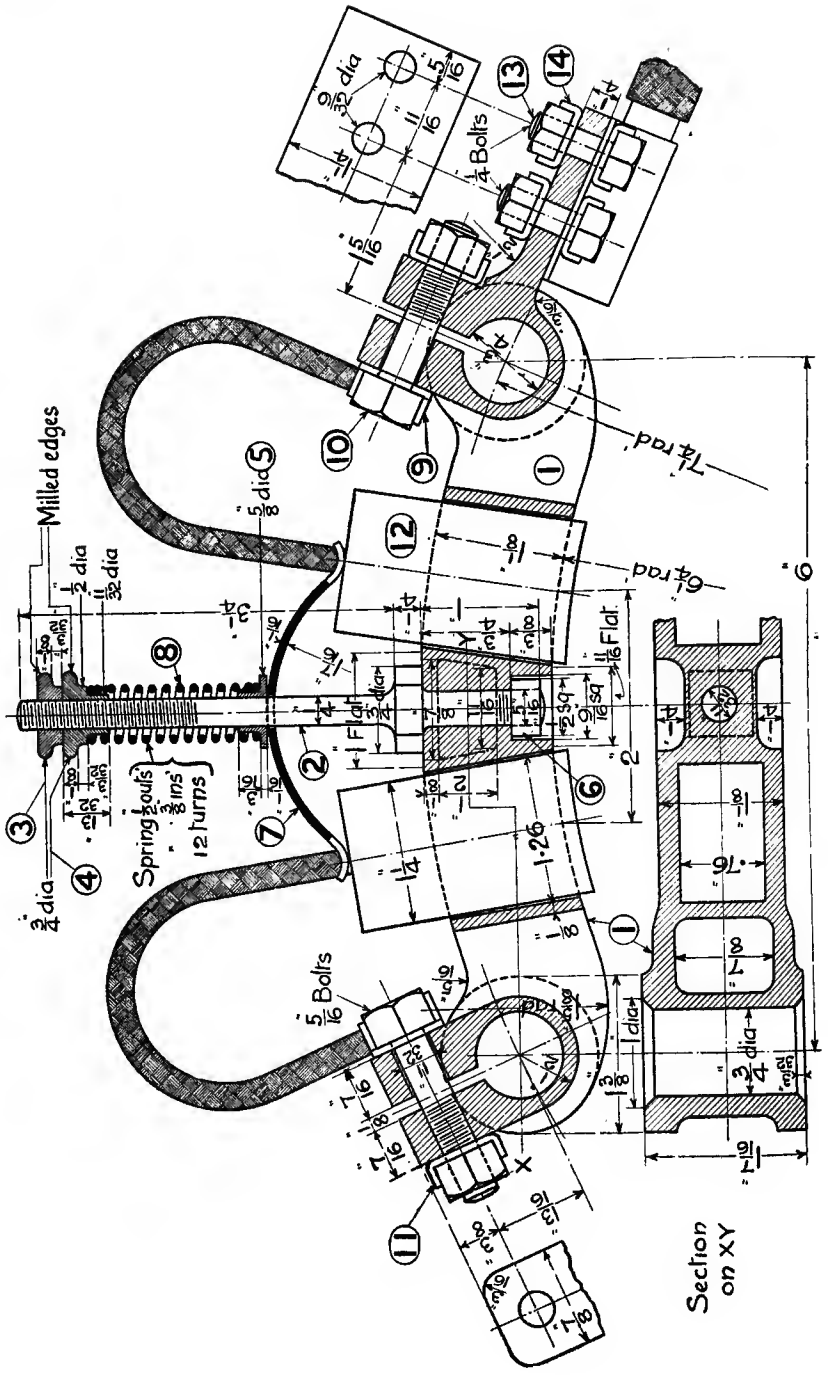
Example 101.—Make separate detail working drawings of items 1 and 2. Show two elevations and a plan in each case.

Example 102.—Design a suitable oil-ring cover for the cap and an oil-well cover for item 1. *Note.*—In plan the oil well is $\frac{3}{4}$" wide inside and the metal at each side $\frac{1}{4}$" thick.

Example 103.—Make a drawing showing the bearing and end frame complete, with all parts, 1 to 13 inclusive, in their proper working positions.

Example 104.—Trace the drawing made in Example 103.

PLATE No. 59


Milled edges
Spring 3 ins
12 turns
4 Bolts
5 Bolts
Section on XY
Flat

BRUSH HOLDER FOR ALTERNATING CURRENT GENERATORS

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Brush Holder . . .	Gun Metal	1	376
2	Stud . . .	Mild Steel	1	—
3	Milled Lock Nut . . .	Brass	1	—
4	,, Adjusting Nut . .	,,	1	—
5	Special Washer for Spring .	,,	1	—
6	Square Nut ($\frac{1}{2}$″ sq., $\frac{1}{4}$″ thick) .	Mild Steel	1	Tapped $\frac{5}{16}$″ dia.
7	Plate Spring . .	Spring Steel	1	$3\frac{1}{2}$″ × $\frac{3}{4}$″ × $\frac{1}{16}$″
8	Helical Spring . .	,,	1	$1\frac{1}{2}$″ long, uncompressed

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
9	Terminals for Flexibles . .	Copper	2	$1\frac{3}{4}$″ × $\frac{3}{4}$″ × 16s S.W.G.
10	Hex. Hd. Bolts and Nuts (screwed 1″ of length)	Mild Steel	2	$\frac{5}{16}$″ × $1\frac{1}{2}$″
11	Pfeil Lock Washers . .	,,	2	$\frac{5}{16}$″
12	Brushes with "Flexibles" Complete	Carbon	2	$1\frac{1}{4}$″ × $\frac{3}{4}$″ × 2″
13	Hex. Hd. Bolts and Nuts .	Mild Steel	2	$\frac{1}{4}$″ × $\frac{3}{4}$″
14	Pfeil Lock Washers . .	,,	2	$\frac{1}{4}$″

The Brush Holder shown on this plate is such as is used on the Slip Rings of Alternating Current Generators and Motors. The holder is carried on two spindles (being insulated therefrom) which, with insulating bushes, fit the two $\frac{3}{4}$″ holes in the ends of the holder.

The spindles, which are not shown in the illustration, are mounted on a suitable bracket on the frame of the machine.

The brushes (item **12**) are an easy fit in the holder, and good electrical connection between each brush and the holder is obtained by means of the flexible cables which are formed in the brush at one end and attached at the other to the holder by the terminals (**9**) and the bolts (**10**).

By the arrangement of springs shown in the illustration, the pressure of the brushes on the slip rings may not only be easily adjusted, but the pressure on both brushes is uniform.

Example 105.—Make full size detail working drawings of items **1** and **2**.

Example 106.—Design a similar brush holder, complete, for brushes $\frac{3}{4}$″ × $\frac{3}{4}$″ × $2\frac{1}{8}$″. Make the holes for the spindles $\frac{5}{8}$″ diameter and at 5″ centres.

Assume the slip ring to be 10″ diameter, and allow the brushes to project $\frac{1}{8}$″ below the bottom edge of the brush holder.

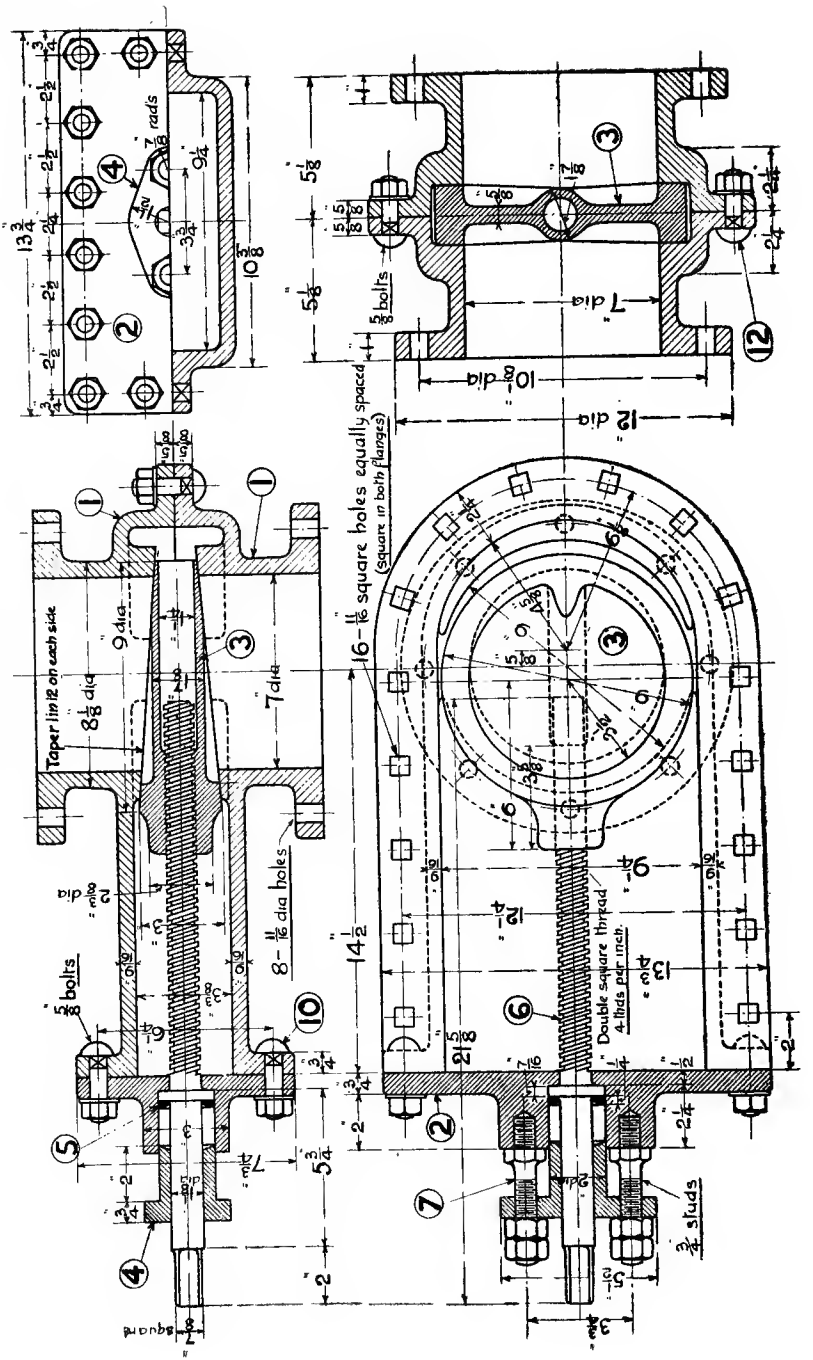
$\frac{1}{4}$″ bolts may be used instead of $\frac{5}{16}$″ (item **10**) and $\frac{3}{16}$″ instead of $\frac{1}{4}$″ (item **13**).

In other respects the design may be similar to the one shown.

SECTION VII

HYDRAULIC ENGINEERING

PLATE No. 60


Taper 1in 12 on each side
8 1/8 dia
9 dia
7 dia
8 - 11/16 dia holes
5/8 bolts
16 - 11/16 square holes equally spaced (square in both flanges)
14 1/2
10 3/8 dia
12 dia
7 dia
5/8 bolts
Double square thread 4 threads per inch
3/4 studs
7 rads

HYDRAULIC STOP VALVE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Stop Valve Body (in halves) .	Cast Iron	2 halves	307
2	,, ,, Cover .	,,	1	308
3	Valve . . .	Gun Metal	1	309
4	Gland . .	,,	1	310
5	Neck Bush	,,	1	311
6	Spindle (screwed part, $1\frac{1}{8}$" dia.)	Phosphor Bronze	1	$21\frac{3}{8}$" long
7	Studs for Gland	Mild Steel	2	Special
8	Hex. Nuts	Mild Steel	2	$\frac{3}{4}$"
9	Hex Lock Nuts . .	,,	2	$\frac{3}{4}$"
10	Cup. Hd. Bolts, with Hex. Nuts (cover)	Wro't Iron	16	$\frac{5}{8}$" × $2\frac{3}{4}$"
11	Washers	,,	16	$\frac{5}{8}$"
12	Cup Hd. Bolts, with Hex. Nuts (body)	,,	16	$\frac{5}{8}$" × $2\frac{1}{2}$"
13	Washers . . .	,,	16	$\frac{5}{8}$"

Various views of a 7" Hydraulic Stop Valve are given on this plate. The body of such a valve is frequently made in one casting. Making it in halves, as in the illustration, facilitates the machining of the valve seats considerably, but incidentally introduces the necessity for the making of a joint which is absent in the case of the single casting body. All bolt holes are clearance holes.

Example 107.—Make separate detail working drawings of each of the following items; **1, 2, 3, 4, 5, 6,** and **7.**

Example 108.—Design a 4" stop valve similar to the one illustrated, but working as closely as possible to the following dimensions:—

Diameter of valve, $5\frac{1}{2}$". Diameter of spindle, 1".

Height from centre of valve opening to underside of cover, 10". (This dimension is $14\frac{1}{2}$" on the 7" valve, illustrated.)

Diameter of circular flanges on body, 9". Thickness, $\frac{7}{8}$".

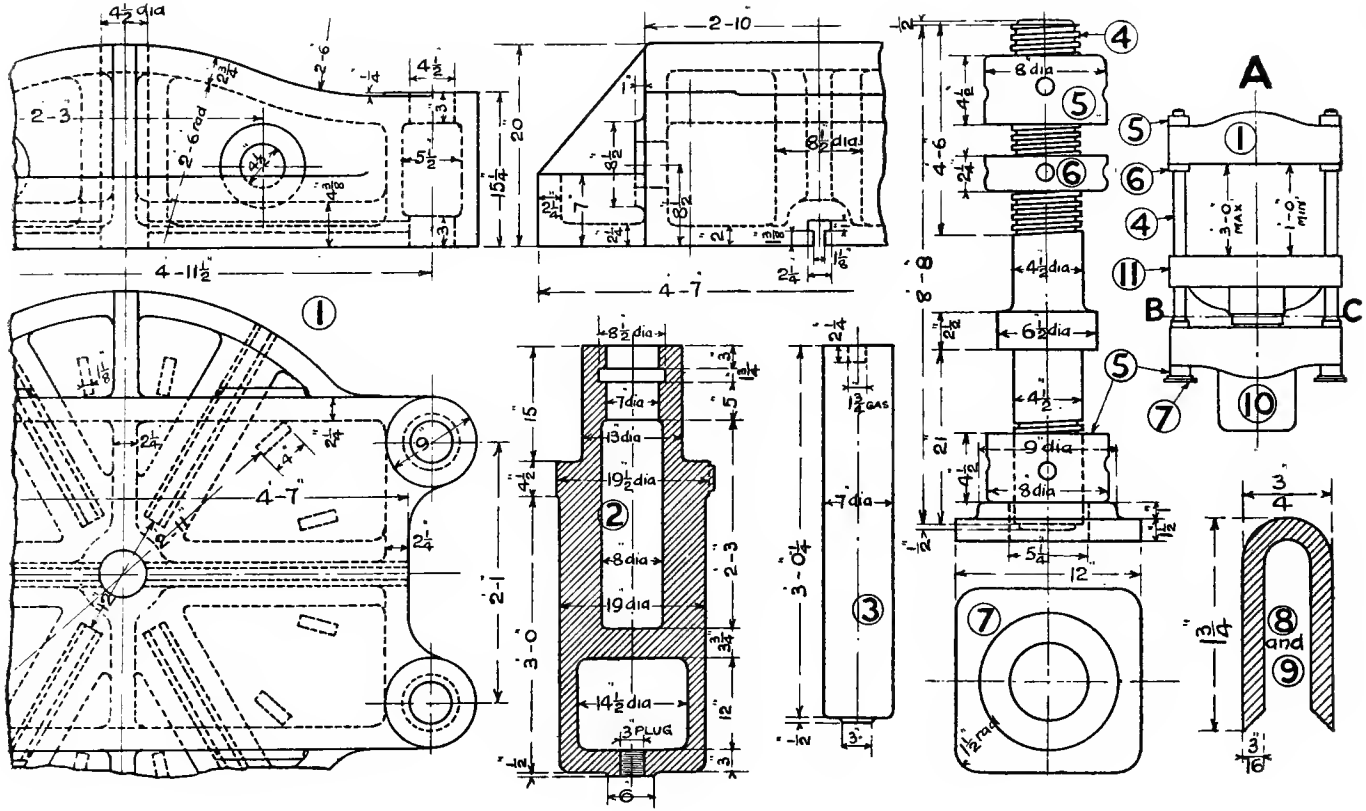
Distance between faces of circular flanges, $9\frac{1}{2}$".

Bolt holes in circular flanges to suit British Engineering Standards requirements.

Inside dimensions of body, $5\frac{3}{4}$" × 3". Thickness of metal in sides, $\frac{1}{2}$". Diameter of stuffing box, $1\frac{3}{4}$". Gland studs, $\frac{5}{8}$" diameter. Use fourteen bolts, $\frac{1}{2}$" diameter, for fixing cover, and fourteen of the same size, for fixing the two halves of the body together.

Example 109.—Trace the drawing made to Example 107 or 108.

PLATE No. 61


4½ dia
2-3
2-6 rad
4-11½
2-10
8½ dia
4-7
1
4-7
2
8½ dia
7 dia
13 dia
19½ dia
8 dia
19 dia
14½ dia
3" PLUG
6
3
2½ GAS
7 dia
3-0¼
4
8 dia
4½ dia
6½ dia
4½ dia
9 dia
8 dia
5¼
12
8-8
4-6
A
B
C
1
3-0 MAX
1-0 MIN
10
7
8 and 9
1½ rad
3/16

200 TONS HYDRAULIC PRESS

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Press Top	Cast Iron	1	1456
2	Main Ram	,,	1	1457
3	Internal Ram .	,,	1	1458
4	Columns	Mild Steel	4	—
5	Circular Nuts . .		8	—
6	,, ,, . . .	,,	4	—
7	Base Plates for Columns .	Cast Iron	4	1459
8	U Packing Ring . . .	Leather	1	$8\frac{1}{2}$″ outs. dia.
9	,, ,, .	,	1	$20\frac{1}{2}$″ outs. dia.

Some details of a 200 Tons Hydraulic Press are illustrated on this plate, other details appearing on Plate No. 62.

The small scale view at A shows the parts assembled together in their working positions.

The main ram is 19″ diameter and has a stroke of 24″. The internal ram is 7″ diameter and has a stroke of 26″. The press is suitable for a working pressure of 1,600 lbs. □ ″.

Such a press is used in the flanging of plates. The internal ram holds the plate in position against the upper flanging block, the actual flanging of the plate being done through the agency of the main ram.

By varying the position of the press top by means of the circular nuts on the columns the range of the opening may be varied from one to three feet. The columns are screwed for a length of 54″ at one end and 7″ at the other end, the threads being square and $\frac{1}{2}$″ pitch.

A section of the leather (packing) rings (8 and 9) is given in the right-hand bottom corner of the illustration.

Example 110.—Make separate detail working drawings of items 1 and 4.

Example 111.—Make a complete general arrangement of the press showing two elevations and two plans. Let one elevation correspond to the outline view at A, but to be a sectional elevation. Take the section nominally on the centre line of the press but in front of any webs that may happen to be on the centre. Make one plan an outside view and the other a section, taking the section on line BC.

PLATE No. 62

200 TONS HYDRAULIC PRESS

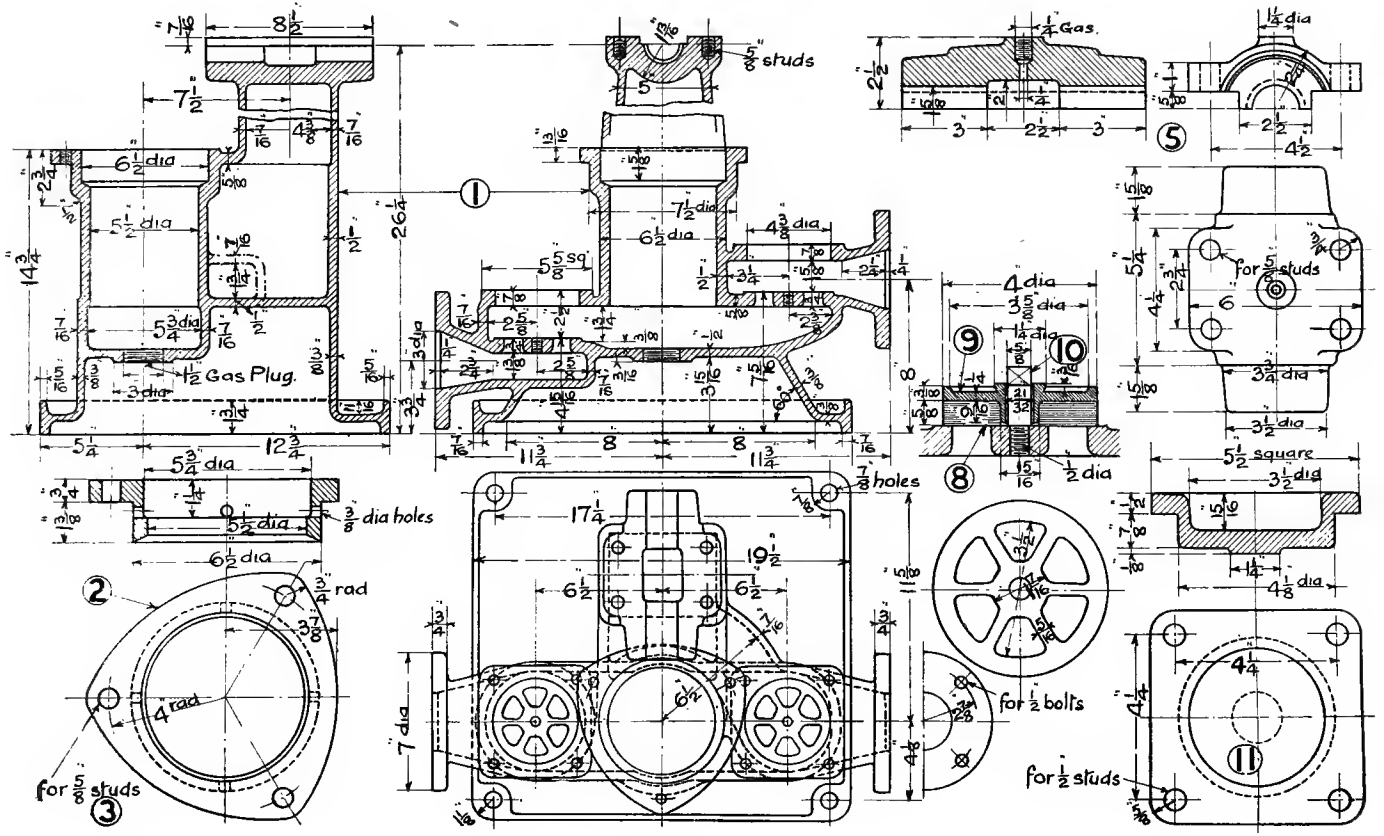
Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
10	Press Base and Cylinder .	Cast Iron	1	1460
11	Cross-head . . .	,,	1	1461

The Cylinder and Cross-head for a 200 Tons Hydraulic Press are shown on the plate facing this page. The other details, together with an outline arrangement of the press, are given on Plate No. 61. The views given here are conventional and incomplete.

Example 112.—Make a complete working drawing of each of the items **10** and **11**. In each case complete the views given and add an end elevation. To be made on separate sheets of paper to as large a scale as convenient.

The details shown on this plate are to be embodied in the general arrangement drawing called for on the preceding page.

PLATE No. 63


1
2
3
4
5
8
9
10
11
studs
Gas.
dia
for studs
for ½ bolts
for ½ studs
holes
rad
square

SINGLE RAM PUMP

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
1	Body	Cast Iron	1	931
2	Gland	,,	1	932
3	Studs for Gland (screwed $2\frac{1}{2}''$ and $1\frac{3}{8}''$)	Mild Steel	3	$\frac{5}{8}'' \times 3\frac{1}{2}''$
4	Hex. Nuts for Studs . .	,,	3	$\frac{5}{8}''$
5	Bearing Cap	Cast Iron	1	933
6	Studs for Bearing Cap (screwed 1″ at each end)	Mild Steel	4	$\frac{5}{8}'' \times 2\frac{3}{4}''$
7	Hex. Nuts for Studs for Bearing Cap	,,	4	$\frac{5}{8}''$

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
8	Valves	Rubber	2	4″ dia. $\frac{5}{8}''$ thick
9	Guards for Valves . .	Brass	2	934
10	Guide Studs	Muntz Metal	2	$\frac{5}{8}'' \times 2\frac{5}{16}''$
11	Valve Box Covers . . .	Cast Iron	2	935
12	Studs for Valve Box Covers (screwed $\frac{5}{8}''$ at each end)	Mild Steel	8	$\frac{1}{2}'' \times 1\frac{1}{2}''$
13	Hex. Nuts for Studs . .	,,	8	$\frac{1}{2}''$
14	Gas Plug	,,	1	$1\frac{1}{2}''$

Some details of a $5\frac{1}{2}'' \times 5''$ Vertical Single Ram Pump are given on the plate facing this page, the remaining details appearing on the following plate, No. 64.

Pumps of this design are specially adapted for purposes where small quantities of water are to be delivered against moderate heads, such as feeding the water tanks in hotels and country houses. They may also be used for pumping the circulating water for the cooling of gas engines, etc.

The capacity of the pump illustrated is 1,700 gallons per hour when running at 70 r.p.m., the maximum "head" being 100 feet.

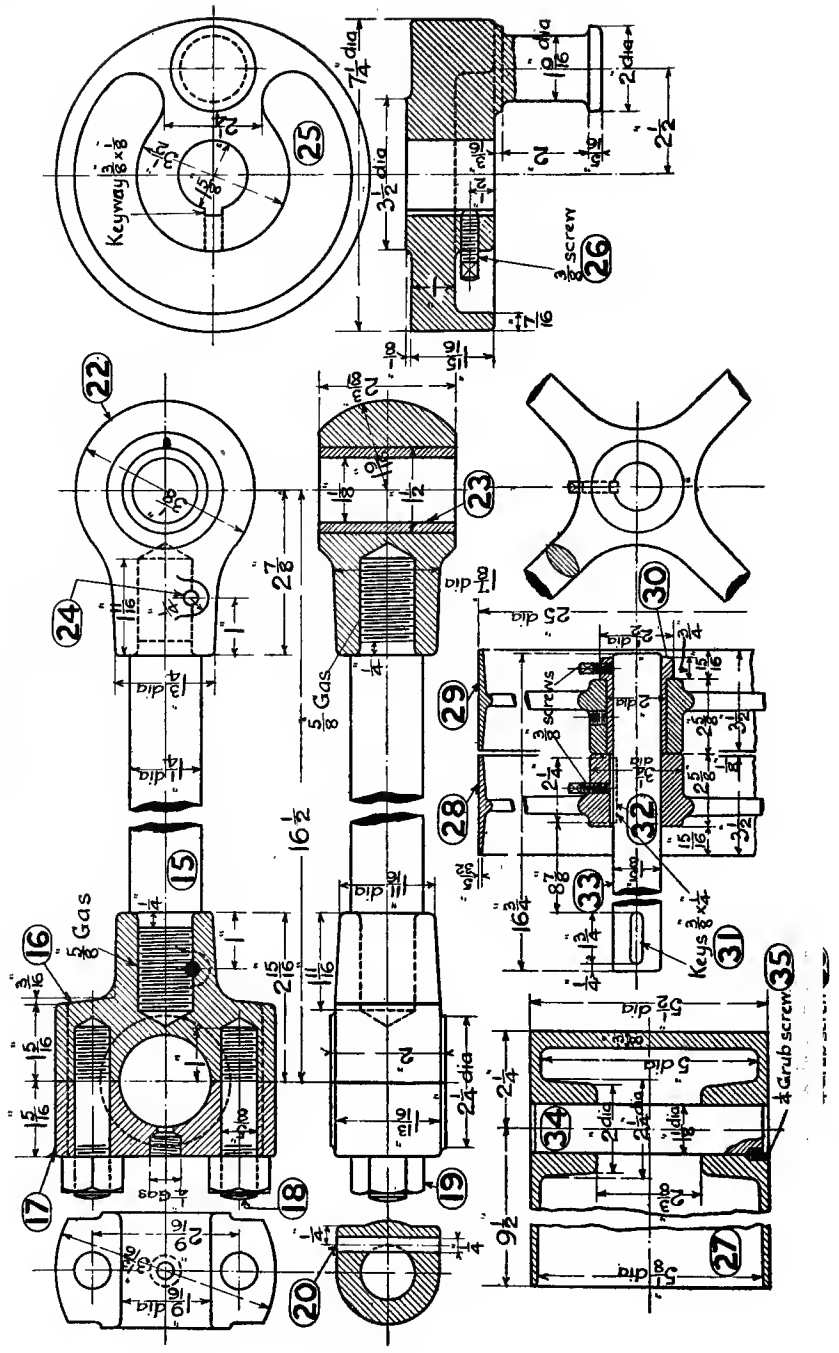
Example 113.—Make a drawing (to as large a scale as your drawing paper permits) showing the pump body with all the details (items **2** to **14**) in their proper working positions.

Two sectional elevations (corresponding to those given of item **1**) are to be shown, and an outside view plan. Show the plan view with one of the valve box covers removed. The drawing must be fully dimensioned as for a working drawing.

Example 114.—Make a general arrangement of the complete pump showing two elevations and a plan.

Each view to be an **outside view**, and no unseen parts are to be indicated. This drawing is not to be dimensioned, and should be shade-lined in the manner shown in the outside view elevation of the steam hammer on Plate No. 92, i.e. upper and left-hand edges indicated by thin lines, lower and right-hand edges by thick lines.

PLATE No. 64


Keyway 3/8 x 1/8
3/8 screw
Keys 3/8 x 1/4
4 Grub screws
3 screws
5/8 Gas
16½
25 dia
22
23
24
25
26
27
28
29
30
31
32
33
34
35

SINGLE RAM PUMP

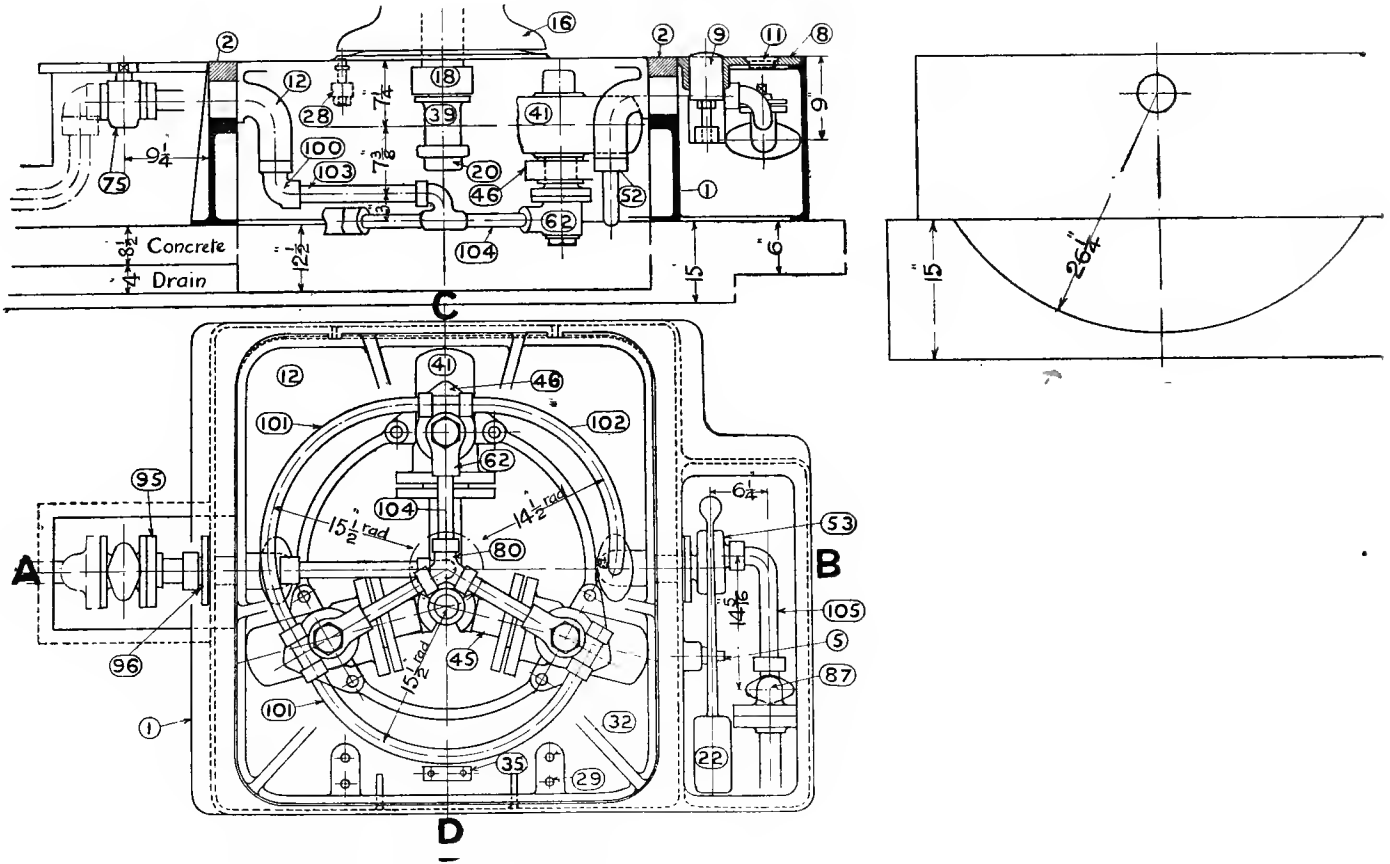
Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
15	Connecting Rod . . .	Mild Steel	1	$1\frac{1}{4}$″ dia. $14\frac{1}{16}$″ long
16	,, ,, End (large)	Gun Metal	1	936
17	,, ,, ,, Cap .	,,	1	937
18	Studs for Cap (screwed $\frac{1}{8}$″ at each end)	Mild Steel	2	$\frac{5}{8}$″ × 3″
19	Hex. Nuts for Studs . .	,,	2	$\frac{5}{8}$″
20	Locking Pin . . .	,,	1	$\frac{1}{4}$″ × $1\frac{1}{8}$″
21	Lubricator	Brass	1	$\frac{1}{4}$″ gas
22	Connecting Rod End (small) .	Gun Metal	1	938
23	Bush for Connecting Rod End (small)	,,	1	939
24	Locking Pin	Mild Steel	1	$\frac{1}{4}$″ × $1\frac{1}{8}$″
25	Crank Disc and Pin . .	Cast Iron	1	940
26	Sq. Hd. Set Screw for Disc and Pulleys	Mild Steel	3	$\frac{5}{8}$″ × 1″
27	Plunger	Gun Metal	1	941
28	Fast Pulley	Cast Iron	1	942
29	Loose ,, ...	,,	1	942
30	Bush for Loose Pulley . .	Gun Metal	1	943
31	Key for Crank Disc . .	Key Steel	1	$\frac{3}{8}$″ × $\frac{1}{4}$″ × $1\frac{3}{4}$″
32	,, ,, Fast Pulley . .	,,	1	$\frac{3}{8}$″ × $\frac{1}{4}$″ × $2\frac{1}{4}$″
33	Shaft	Mild Steel	1	$1\frac{5}{8}$″ dia. $16\frac{3}{4}$″ long
34	Gudgeon Pin	,,	1	$1\frac{1}{8}$″ dia. $5\frac{5}{8}$″ long
35	Grub Screw for Gudgeon Pin	,,	1	$\frac{1}{4}$″ dia. $\frac{3}{8}$″ long
36	Stauffer Lubricator . .	Brass	1	No. 3 or 4.

Further details of a $5\frac{1}{2}$″ × 5″ Vertical Single Ram Pump are given on the plate facing this page, the other details being illustrated on the preceding plate, No. 63.

Example 115.—Make a drawing of the shaft (item **33**) with the fast and loose pulleys and the crank disc in their respective working positions. Sufficient views are to be given to make a working drawing, i.e. the complete shape of each part is to be indicated and fully dimensioned, the following items being included in the drawing: **25**, **26**, **28**, **29**, **30**, **31**, **32**, and **33**. A No. 3 or No. 4 Stauffer lubricator to be shown screwed into the tapped hole in the hub of the loose pulley. This hole is $\frac{1}{4}$″ gas. The arms of the pulleys are $1\frac{3}{4}$″ wide × $\frac{7}{8}$″ thick near the hub, tapering to $1\frac{1}{4}$″ wide × $\frac{5}{8}$″ thick at the rim.

Example 116.—Trace the drawing made in Example 115.

PLATE No. 65



HYDRAULIC CAPSTAN

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
101	Water Pipes	Wrought Iron	2	$1\frac{1}{4}$" bore $35\frac{1}{2}$" long
102	,, ,, ...	,,	1	$1\frac{1}{4}$" bore 33" long
103	,, ,, ...	,,	1	$1\frac{1}{2}$" bore $14\frac{1}{4}$" long
104	,, ,, ...	,,	3	$1\frac{1}{4}$" bore $9\frac{1}{2}$" long
105	,, . .	Copper	1	$1\frac{1}{2}$" bore $14\frac{1}{2}$" long

Incomplete general arrangement views of a Hydraulic Capstan are given on this plate, complete detail drawings of the various parts appearing on Plates Nos. 66 to 71 inclusive.

Such capstans are used in running sheds and the yards of railway companies for hauling wagons, etc. The capstan illustrated is suitable for a working pressure of 750 lbs. per square inch.

As nearly the whole of the working parts are situated below the ground level, the main plate (**12**), carrying these parts, is itself carried on two trunnions, so that when any of the working parts require attention the whole may be easily turned over and rendered accessible.

The concrete foundation has its centre portion scooped out to clear the plate when this operation is carried out.

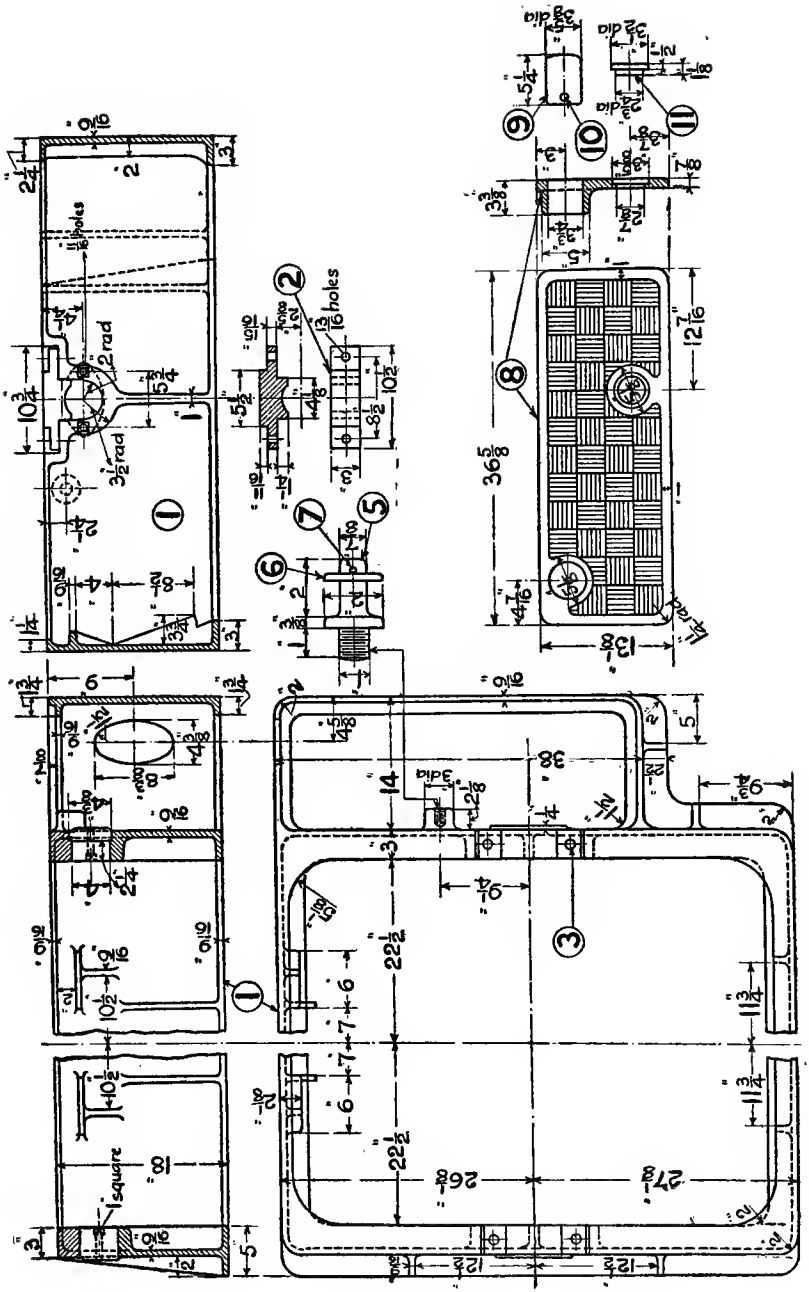
The working of the capstan is as follows: After the H.P. water valve (**87**) is opened the running of the capstan is controlled by the treadle valve (**53**). A slight pressure on pin (**9**) depresses the small end of lever (**22**) which turns about pin (**5**) and operates valve (**53**). The water then passes through pipes (**102** and **101**) and through the valves (**62**) to the cylinders (**41**).

It will be noted that there are three cylinders and valves arranged at 120° to each other. This arrangement ensures that there is no "dead point," i.e. that there is no position of crank pin in which the turning effect of the plungers on the crank shaft is insufficient to overcome the normal resistance. The valves (**62**) also regulate the discharge of water from the cylinders. From the valves the water passes to the four-way union (**80**) and thence through the return water-cock (**75**) to the low pressure main.

The views given are conventional ones, the plan being an inverted plan.

Example 117.—Make a general arrangement of the complete capstan, showing two elevations and two plans. Let both elevations be sectional, the sections being taken on lines AB and CD respectively. Let one plan be an ordinary outside view plan and the other plan "inverted," as in the illustration. This example should not be drawn until the detail work connected with the capstan on the following plates is finished.

PLATE No. 66



BEDPLATE AND DETAILS FOR HYDRAULIC CAPSTAN

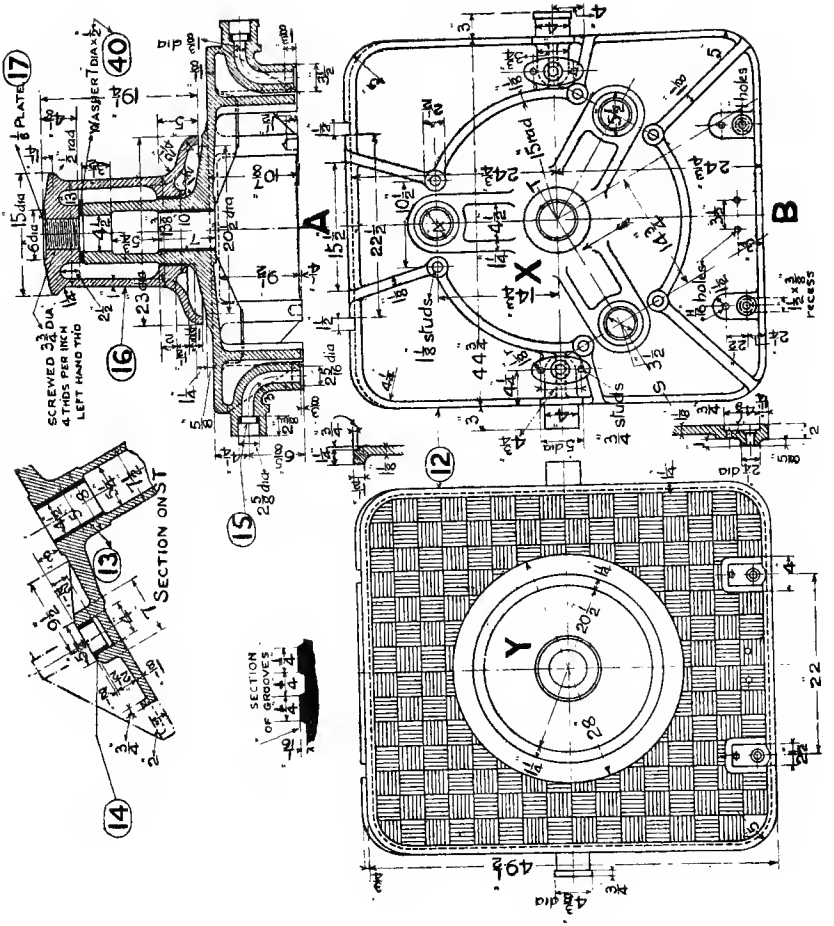
Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Bedplate	Cast Iron	1	301
2	Caps for Bearings	,,	2	302
3	Studs for Caps (screwed 1″ at each end)	Mild Steel	4	$\frac{3}{4}$″ × 2$\frac{3}{4}$″
4	Hex. Nuts for Studs	,,	4	$\frac{3}{4}$″
5	Fulcrum Stud for Treadle	,,	1	—
6	Washer for Fulcrum Stud for Treadle	,,	1	2″ dia. $\frac{5}{16}$″ thick
7	Pin for Washer	,,	1	$\frac{3}{16}$″ dia. 2″ long
8	Cover Plate for Treadle Valve, etc.	Cast Iron	1	303
9	Treadle Pin	Mild Steel	1	3$\frac{5}{8}$″ dia. 5$\frac{1}{4}$″ long
10	Split Pin for Treadle Pin	,,	1	$\frac{1}{2}$″ dia. 5″ long
11	Loose Cover for Stop Valve	Cast Iron	1	304

Separate details of the component parts of the Capstan Bedplate are shown on the plate facing this page. The functions of the various parts are indicated on Plate No. 65 and its accompanying text.

Example 118.—Make a drawing to a scale of 3″ = 1′, showing the bedplate complete with items 2 to 11 in their working positions. Such views are to be given and dimensioned that the whole of the parts indicated may be made from the drawing.

The checquering of the cover-plate (item 8) is similar to that of the revolving plate (item 12) particulars of which are given on Plate No. 67.

PLATE No. 67


A
B
X
Y
SECTION ONST
SECTION OF GROOVES
SCREWED 3¼ DIA 4 THDS PER INCH LEFT HAND THD
WASHER DIA
PLATE
18 studs
3 studs
holes
recess
dia

REVOLVING PLATE, BOLLARD, ETC., FOR HYDRAULIC CAPSTAN

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
12	Revolving Plate . . .	Cast Iron	1	305
13	Centre Bearing Bush	Gun Metal	1	306
14	Cylinder Bearing Bushes	,,	3	307
15	Neck Bushes ($2\frac{5}{8}$″ outs. dia., 2″ ins. dia., $\frac{3}{4}$″ long)	,,	2	308
16	Bollard	Cast Iron	1	309
17	,, Top Plate .	Wrought Iron	1	6″ dia. $\frac{1}{8}$″ thick

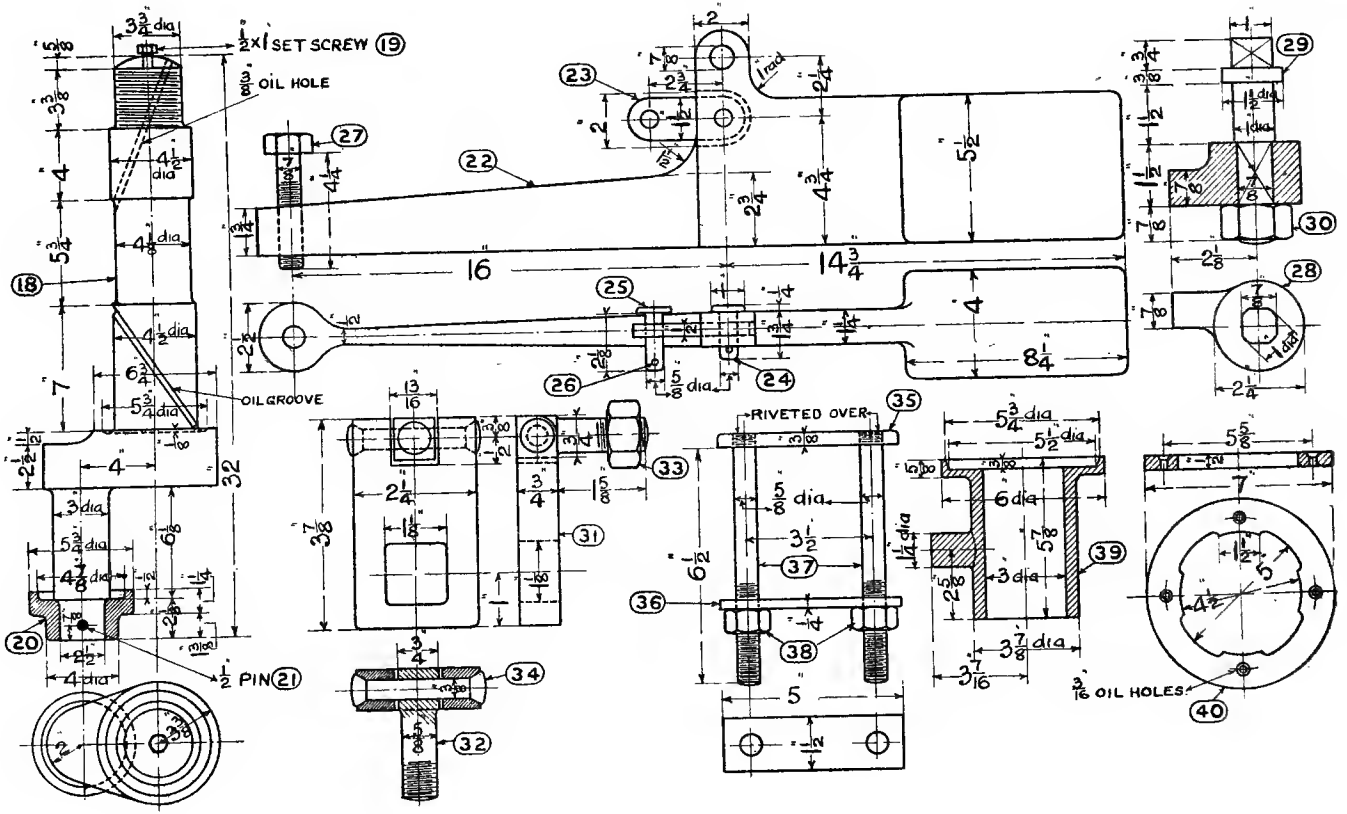
The illustration facing this page shows the Revolving Plate and Bollard for the Hydraulic Capstan described on page 161. The view X is an inverted plan of the plate, the ordinary plan being shown by view Y.

Particulars of the washer (item **40**) are given on Plate No. 68.

Example 119.—Make separate detail working drawings of items **12** and **16**.

The drawing of the plate (item **12**) must show the three main views indicated in the illustration (but showing the revolving plate only). Then, instead of the auxiliary view showing a section on ST, make a complete sectional elevation, taking the section on line AB.

PLATE No. 68


2 x 1 SET SCREW (19)
OIL HOLE
OIL GROOVE
(18)
(20)
½ PIN (21)
(22)
(23)
(24)
(25)
(26)
(27)
16
14¾
8¼
(28)
(29)
(30)
(31)
(32)
(33)
(34)
RIVETED OVER
(35)
(36)
(37)
(38)
(39)
(40)
3/16 OIL HOLES

CRANK SHAFT, TREADLE LEVER, ETC., FOR HYDRAULIC CAPSTAN

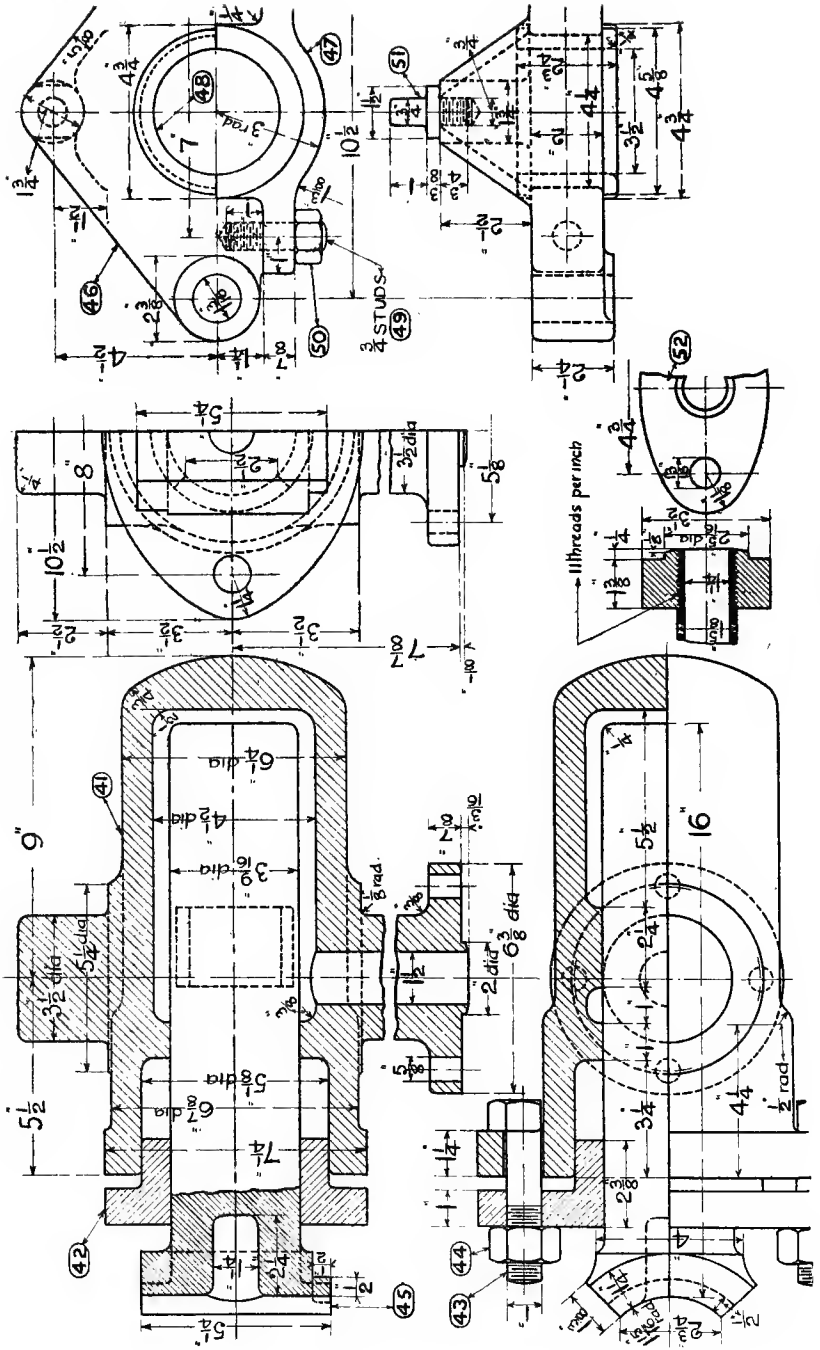
Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
18	Crank Shaft	Mild Steel	1	—
19	Hex. Hd. Set Bolt	,,	1	$\frac{1}{2}'' \times 1''$
20	Collar for Crank Pin	,,	1	—
21	Pin for Collar for Crank Pin	,,	1	$\frac{1}{2}'' \times 4\frac{3}{4}''$
22	Lever for Treadle Valve	Wrought Iron	1	—
23	Link for Lever	,,	1	—
24	Pin for Link	Mild Steel	1	—
25	,, ,,	,,	1	—
26	Split Pins for Pin for Link	,,	2	$\frac{5}{32}'' \times 1\frac{1}{2}''$
27	Hex. Hd. Set Screw	,,	1	$\frac{1}{8}'' \times 4\frac{1}{4}''$
28	Catches for Revolving Plate	Wrought Iron	2	—
29	Fulcrum Pins for Catches	Mild Steel	2	—
30	Hex. Nuts for Pins	,,	2	$\frac{1}{8}''$
31	Check Plates for Catches	,,	2	—
32	Eye-bolts for Check Plates for Catches	,,	2	—
33	Hex. Nuts for Eye-bolts	,,	2	$\frac{5}{8}''$
34	C't's'k Rivets	,,	2	$\frac{3}{8}'' \times 2\frac{1}{2}''$
35	Lifting Shackle (top plate)	,,	1	—
36	,, ,, (bottom plate)	,,	1	—
37	,, ,, Studs (screwed 3″ and $\frac{1}{2}''$)	,,	2	$\frac{5}{8}'' \times 6\frac{3}{4}''$
38	Hex. Nuts for Studs	,,	2	$\frac{5}{8}''$
39	Bush for Crank Pin	Gun Metal	1	310
40	Washer for Bollard	,,	1	311

Example 120.—Draw the elevation and plan of the crank shaft (item **18**), and to the right of the elevation project another elevation at right angles to the first. Items **19**, **20**, and **21** need not be shown.

Example 121.—Draw the elevation and plan of items **22** to **27**, as shown. To the right of this elevation project an end elevation.

In each case insert all dimensions as for a working drawing.

PLATE No. 69



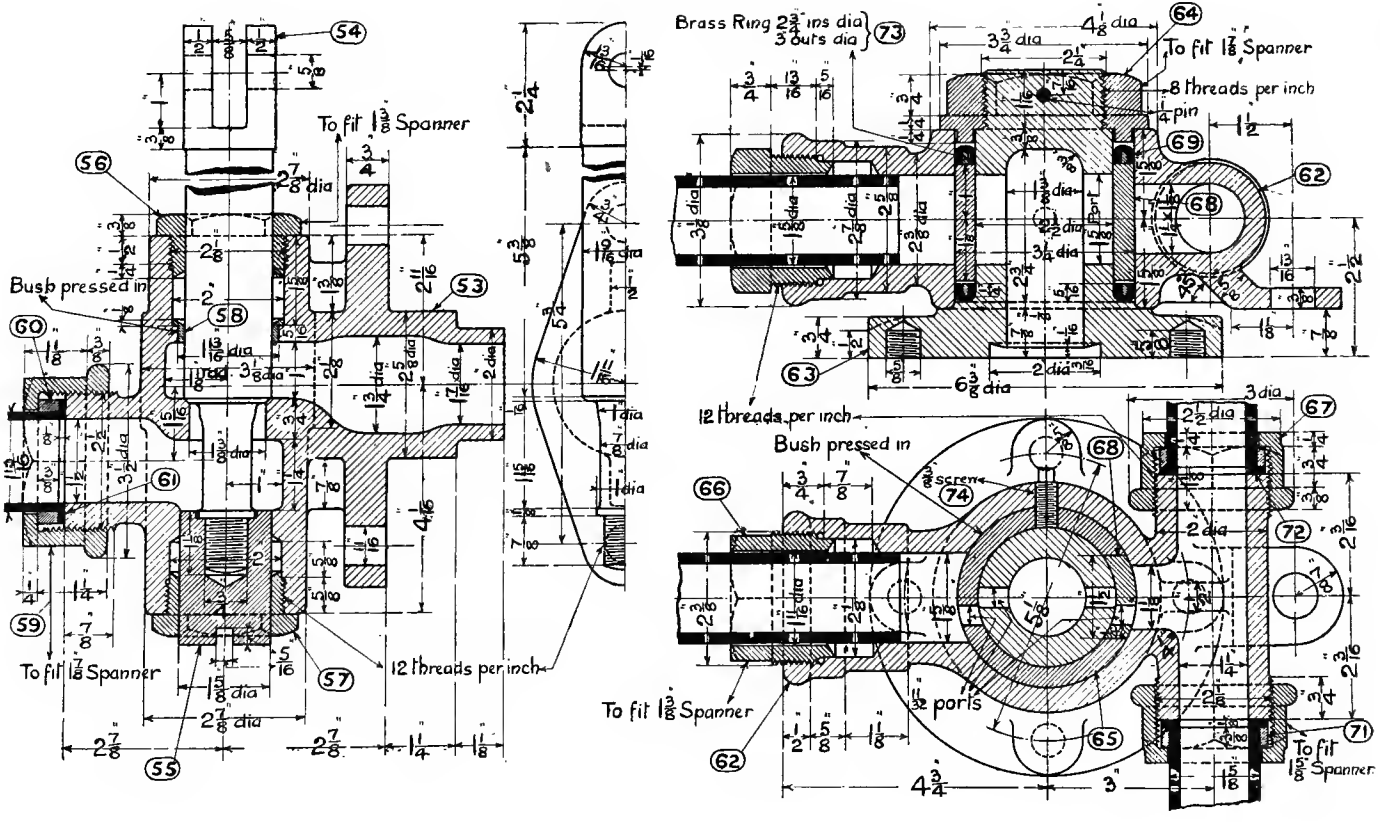
CYLINDERS AND CARRIERS FOR HYDRAULIC CAPSTAN

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
41	Cylinders	Cast Iron	3	312
42	Glands	,,	3	313
43	Hex. Hd. Bolts for Glands	Mild Steel	6	1″ × 4¼″
44	Hex Nuts for Bolts	,,	6	1″
45	Plungers	,,	3	—
46	Carriers for Cylinders	Cast Iron	3	314
47	Caps for Carriers	,,	3	315
48	Half Bushes for Carriers	Gun Metal	3	316
49	Studs for Caps (screwed ⅜″ each end)	Mild Steel	6	¾″ × 2½″
50	Hex. Nuts for Studs	,,	6	¾″
51	Fulcrum Studs	,,	3	—
52	Flange for Pressure Pipe	Gun Metal	1	317

Example 122.—Make **separate** detail working drawings of each of the following items: **41**, **42**, **45**, showing in each instance two elevations and a plan. Scale, half size.

Example 123.—Make a full size drawing of the cylinder carrier, complete (items **46** to **51**, inclusive).
Complete the elevation and plan indicated in the illustration, and add an end elevation. Let the end elevation show a section taken on the vertical centre line of the carrier.

PLATE No. 70


To fit 1⅛ Spanner
Bush pressed in
12 threads per inch
To fit 1⅞ Spanner
Brass Ring 2¾ ins dia 3 outs dia
To fit 1⅛ Spanner
8 threads per inch
pin
12 threads per inch
Bush pressed in
screw
32 ports
To fit 1⅛ Spanner
To fit 1⅝ Spanner

TREADLE VALVE AND CYLINDER FOR HYDRAULIC CAPSTAN

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
53	Treadle Valve Body .	Gun Metal	1	318
54	,, ,, Spindle . .	,,	1	319
55	,, ,, Balance Piston	,,	1	320
56	,, ,, Gland . .	,,	1	321
57	,, ,, Piston Gland	,,	1	321
58	,, ,, Neck Bush	,,	1	322
59	,, ,, Union . .	,,	1	323
60	,, ,, ,, Ferrule .	,,	1	324, $2\frac{1}{4}$″ dia. $1\frac{1}{16}$″ bore
61	,, ,, ,, Washer .	Leather	1	$2\frac{1}{4}$″ dia. $1\frac{1}{2}$″ bore
62	Cylinder Valve Body . .	Gun Metal	3	325
63	,, ,, Centre . .	,,	3	326
64	,, ,, Nut . .	,,	3	327
65	,, ,, Bush	,,	3	328

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
66	Cylinder Valve Gland . .	Gun Metal	3	329
67	,, ,, Union . .	,,	6	330
68	,, ,, Loose Piece for Bush	,,	3	331
69	,, ,, U Leathers .	Leather	6	$\frac{1}{16}$″ thick
70	,, ,, Pins for Nut .	Mild Steel	3	$\frac{1}{4}$″ × 3″
71	,, ,, Ferrules for Unions	Gun Metal	6	$1\frac{7}{8}$″ dia. $1\frac{5}{8}$″ bore
72	,, ,, Washers for Unions	Leather	5	$1\frac{7}{8}$″ dia. $1\frac{1}{4}$″ bore
73	,, ,, Rings for U Leathers	Brass	6	—
74	,, ,, Set Screws for Bushes	,,	3	$\frac{3}{8}$″

Note.—One of the unions (item **67**) is made without the hole in the end, and is used as a cap, there being no pipe connected.

Example 124.—Make separate detail working drawings of each of the following items: **53, 54, 56, 59, 62,** and **63.**

Example 125.—Make a drawing of the treadle valve, complete. Show the sectional elevation as given, complete the end elevation, and add an outside view plan.

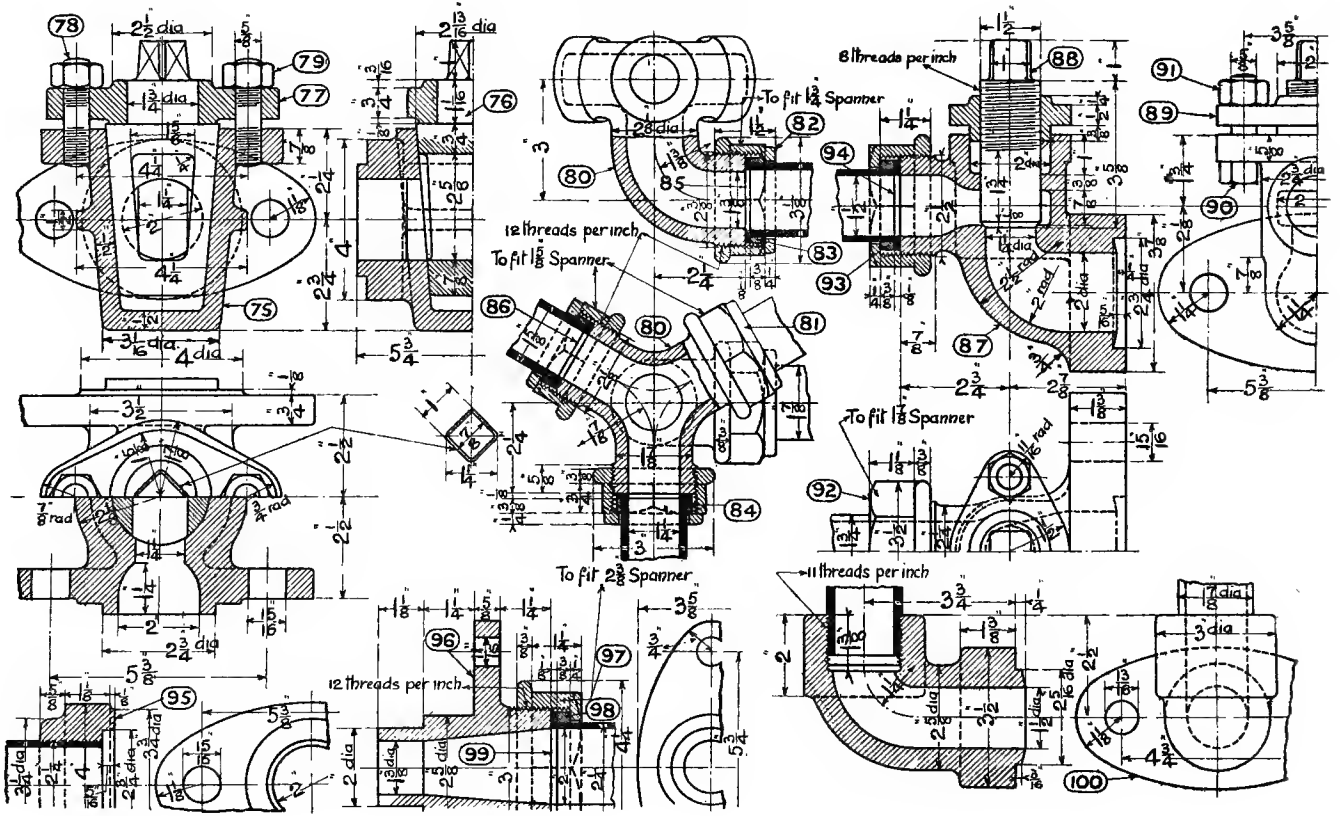
Example 126.—Make a drawing of the cylinder valve, complete. Show the sectional elevation and plan as given, and add an end elevation.

Example 127A.—Trace the drawing made in Example 125.

Example 127B.—Trace the drawing made in Example 126.

Note.—All gland nuts are screwed 12 threads per inch, except where otherwise stated.

PLATE No. 71


To fit 1¾ Spanner
To fit 1⅝ Spanner
To fit 1⅛ Spanner
To fit 2⅜ Spanner
8 threads per inch
12 threads per inch
11 threads per inch
12 threads per inch
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
75	Return Water-cock Body	Cast Iron	1	332
76	,, ,, Plug	Gun Metal	1	333
77	,, ,, Cap .	,,	1	334
78	Studs for Cap (screwed $\frac{7}{8}$″ each end)	Mild Steel	2	$\frac{5}{8}$″ × 2$\frac{1}{2}$″
79	Hex. Nuts for Studs	,,	2	$\frac{5}{8}$″
80	Four-way Union Body . .	Gun Metal	1	335
81	Unions for Four-way Union Body	,,	3	1$\frac{3}{4}$″, 336
82	Union for Four-way Union Body	,,	1	1$\frac{7}{4}$″, 337
83	Ferrule for Unions .	,	1	2$\frac{1}{4}$″ dia. 1$\frac{1}{8}$″ bore
84	,, ,, ,,	,,	3	2″ dia. 1$\frac{1}{8}$″ bore
85	Washers , ,, .	Leather	1	2$\frac{1}{4}$″ dia. 1$\frac{1}{2}$″ bore
86	,, ,, ,, . .	,,	3	2″ dia. 1$\frac{1}{4}$″ bore

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
87	Pressure Valve Body .	Gun Metal	1	338
88	,, ,, Spindle .	,,	1	339
89	,, ,, Gland .	,,	1	340
90	Hex. Hd. Bolts for Gland	Mild Steel	2	$\frac{5}{8}$″ × 2$\frac{1}{4}$″
91	,, Nuts for Bolts . .	,,	2	$\frac{5}{8}$″
92	Pressure Valve Union	Gun Metal	1	341
93	Ferrule for Union . .	,,	1	2$\frac{3}{8}$″ dia. 1$\frac{1}{4}$″ bore
94	Washer ,, , . .	Leather	1	2$\frac{3}{4}$″ dia. 1$\frac{1}{2}$″ bore
95	Pipe Flange .	Cast Iron	1	342
96	Connector .	Gun Metal	1	343
97	,, Union . .	,,	1	344
98	,, ,, Ferrule	,,	1	2$\frac{7}{8}$″ dia. 2$\frac{1}{4}$″ bore
99	,, ,, Washer	Leather	1	2$\frac{7}{8}$″ dia. 2″ bore
100	Pipe Elbow . .	Cast Iron	1	345

Example 128.—Make a working drawing, full size, of a return water-cock similar to the one illustrated (items 75 to 79), but with the following modifications:—

Opening in cock, 2$\frac{1}{2}$″ diameter instead of 2″, the rectangular part of the opening being 1$\frac{5}{8}$″ instead of 1$\frac{1}{4}$″. The passage in the plug to be made to suit. Largest diameter of plug, 3$\frac{1}{8}$″ instead of 2$\frac{13}{16}$″. Length of plug and body to be increased by $\frac{3}{4}$″. $\frac{3}{4}$″ studs to be used for fixing top plate, and the thickness of the top plate to be increased by $\frac{3}{16}$″.

The distance between the faces of the two side flanges to be 6″ instead of 5″, and the flanges are to be 1″ thick. The holes in these flanges to be suitable for 1″ diameter bolts. The thickness of the body casting to be increased from $\frac{1}{2}$″ to $\frac{9}{16}$″.

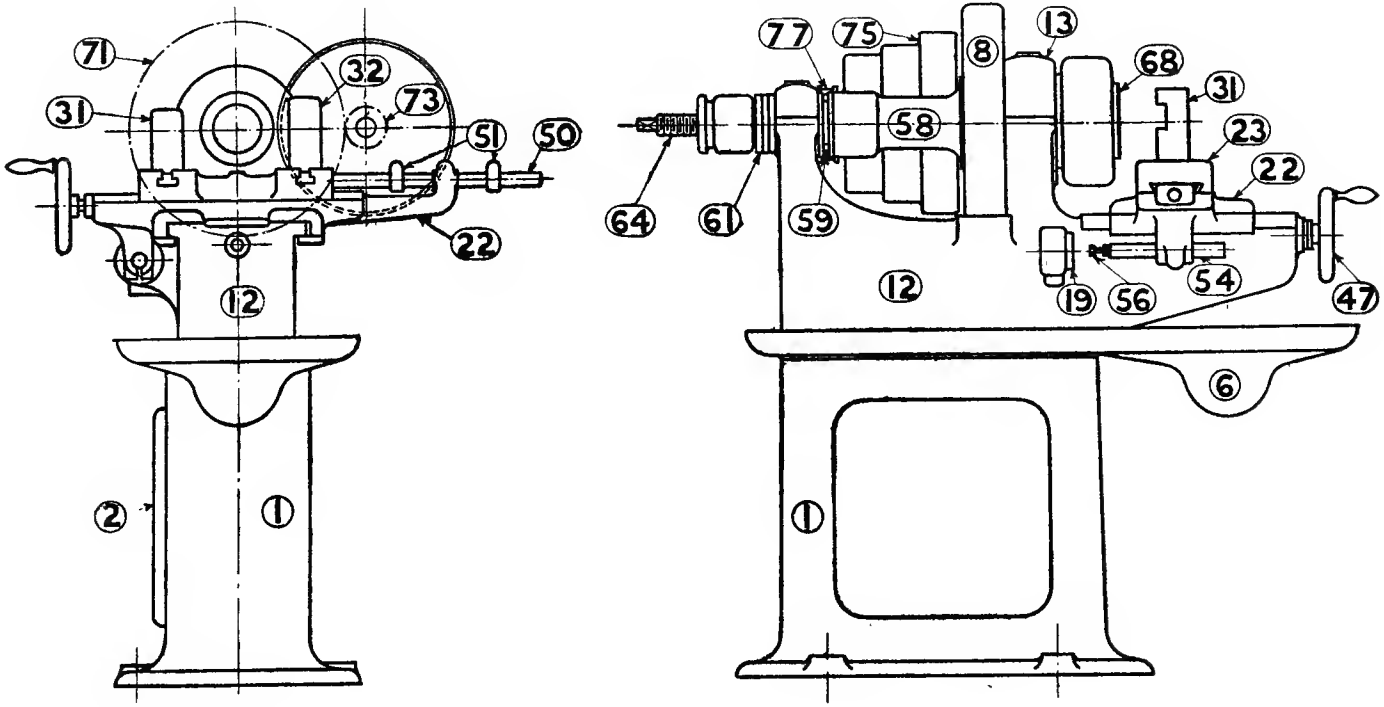
Example 129.—Make a working drawing, full size, of a four-way union similar to the one shown by items 80 to 86, but with the following modifications:—

The three similar unions to be for 1$\frac{1}{2}$″ pipes instead of 1$\frac{1}{4}$″, the remaining union being for a 2″ pipe instead of 1$\frac{1}{2}$″ Distance between horizontal centres of unions to be 3$\frac{3}{4}$″ instead of 3″.

SECTION VIII

MACHINE TOOLS AND JIGS

PLATE No. 72


71
31
32
73
51
50
22
12
2
1
77
75
8
13
68
31
23
22
58
64
61
59
12
19
56
54
47
6
1

SHELL-ENDING LATHE

12 The machine illustrated on this plate was designed specially for the "ending" of 3″ shells. Complete detail drawings of the machine are given on the five succeeding plates.

The machine is driven by belt, and is fitted with a three-speed cone pulley (**75**) and single reduction machine cut spur gearing (**73** and **71**).

All the bearings are fitted with chain lubricators.

The front end of the main spindle (**58**) is enlarged, so that the work passes within and is supported by the front bearing.

A Collett chuck (**68**) of hardened steel is fitted at the front end of the spindle.

Inside the enlarged end of the spindle is a hardened steel disc (**66**) which acts both as a stop and a centraliser for the shell. This stop is adjusted by means of the screw which passes through the spindle to its rear end.

The end thrust on the spindle is taken by the ball thrust washer (**59**), and end play is taken up by the lock nuts (**61**).

The saddle (**22**) is traversed along the bed by a square threaded screw operated by the hand wheel (**47**) at the extreme right-hand end of the machine. A stop rod (**54**) is carried on the saddle, to the front end of which is fitted a screw with lock nut to give the finest adjustments. This stop rod works in conjunction with an eccentric bush (**19**) carried by a bracket on the machine bed, so that the saddle may be brought up to the stop definitely, or, by giving the eccentric bush a half turn, the saddle can be traversed as far as desired towards the chuck.

Fitted to the saddle is a cross-slide (**23**) carrying two tool holders (**31** and **32**), so that cutting off and forming tools, or roughing and finishing tools, may be carried at the same time.

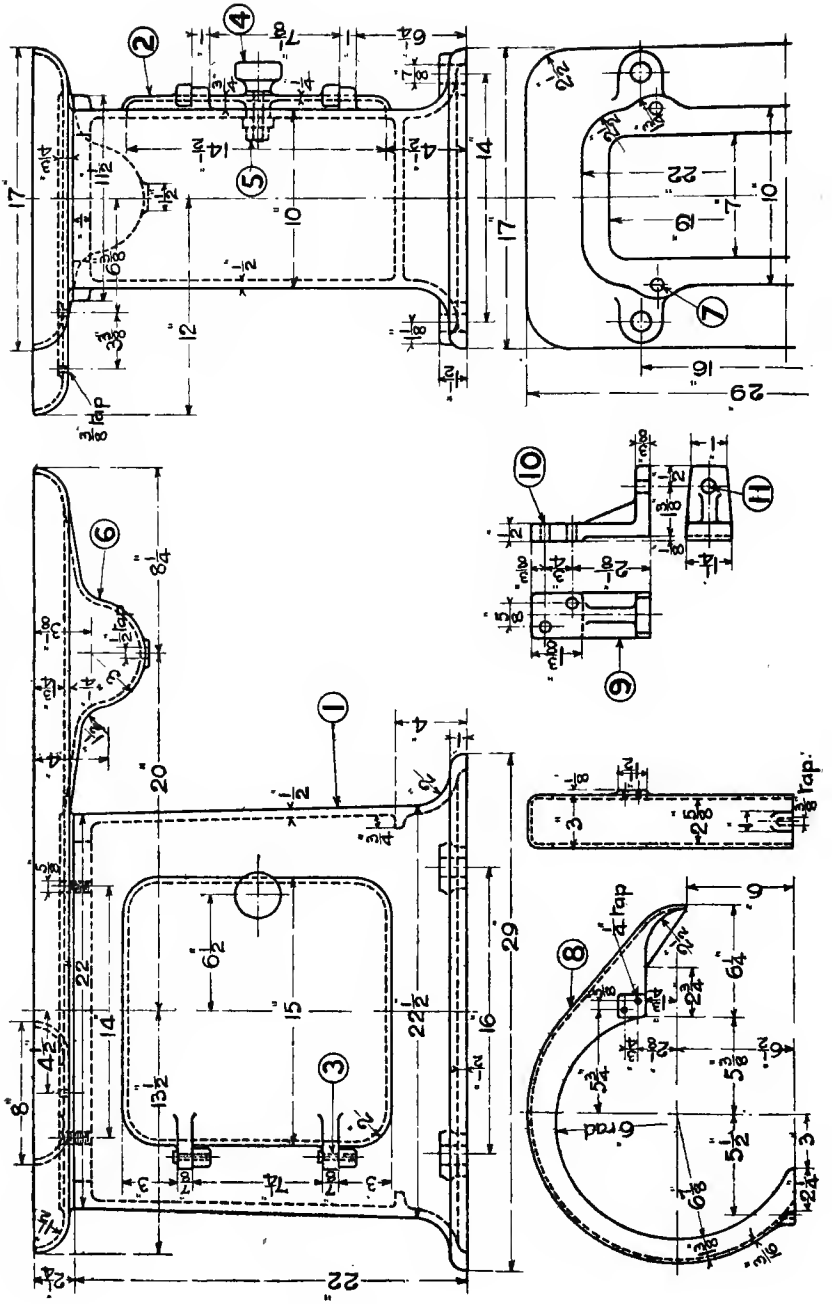
A stop rod (**50**) with stop dogs (**51**) is fitted for both front and rear tools.

A pump is fitted to the machine to supply lubricant to the cutting tools, and is driven by belt from the pulley (**77**). The pump itself is not shown in the illustration.

EXAMPLE 130.—Make a general arrangement drawing of the complete machine, obtaining particulars of the details from Plates No. 73 to 76 inclusive.

Show a front elevation, two end elevations, and a plan. The front elevation is to be sectional, the section being taken on the centre line of the main spindle. Scale, 3″ = 1′.

PLATE No. 73



STAND, ETC., FOR SHELL-ENDING LATHE

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Cabinet Stand	Cast Iron	1	101
2	,, Door		1	102
3	Hinge Pins for Door	,,	2	$\frac{3}{8}''$ × $1\frac{1}{2}''$
4	Handle for Door	Mild Steel	1	—
5	Hex. Nut for Handle	,,	1	$\frac{1}{2}''$
6	Oil Tray	,,	1	103
7	Hex. Hd. Set Bolts	Cast Iron	4	$\frac{5}{8}''$ × 3″
8	Guard for Gearing	Mild Steel	1	104
9	Bracket for Guard	Cast Iron	1	105
10	Hex. Hd. Set Bolts	,,	2	$\frac{1}{4}''$ × 1″
11	,, ,, ,, ,,	Mild Steel	1	$\frac{3}{8}''$ × 1′

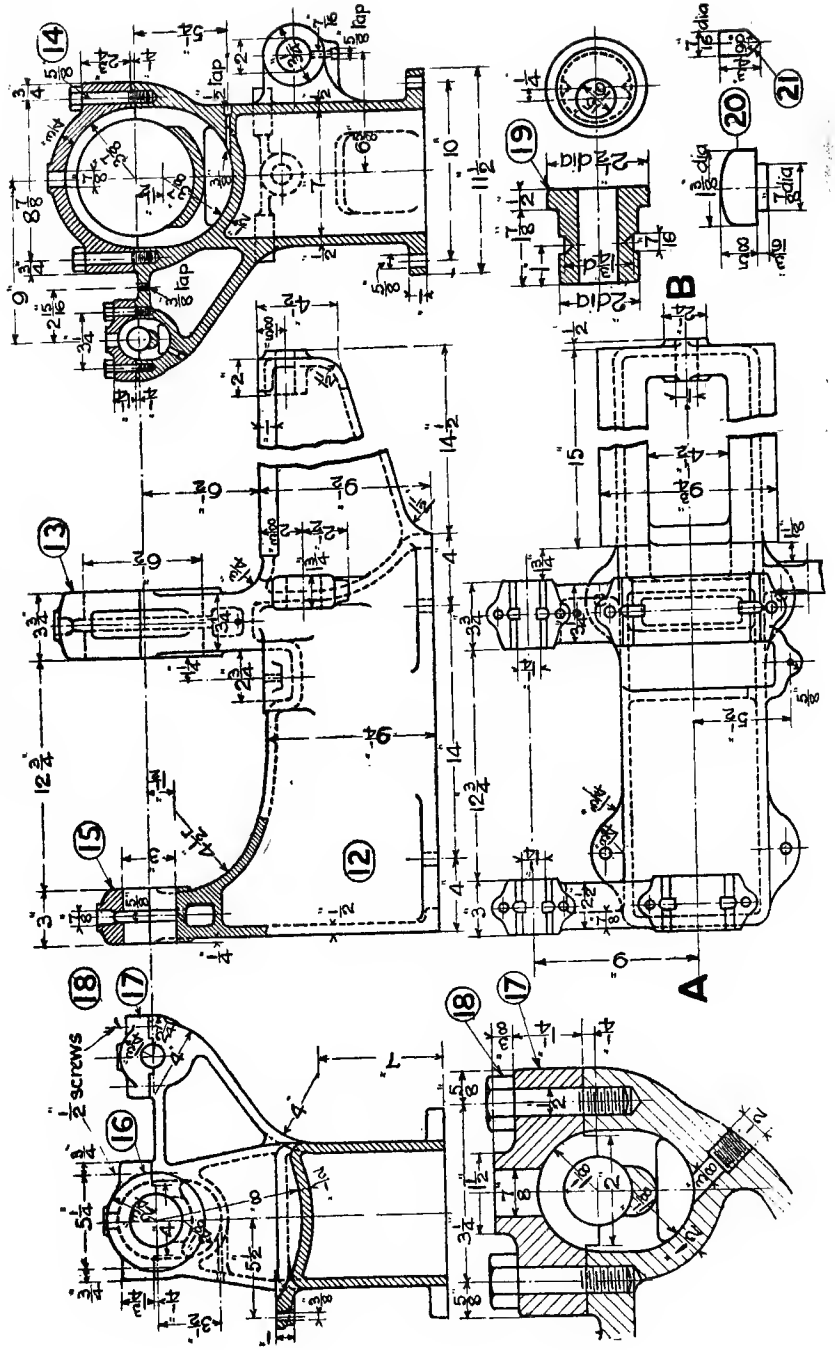
Details of the Stand, Gear Guard, etc., for the Shell-ending Lathe are illustrated on this plate.

The stand casting forms a cabinet fitted with a hinged door. The oil tray is a separate casting, and is fixed to the stand by means of four $\frac{5}{8}''$ hexagonal head set bolts (item 7).

Example 131.—Make separate detail working drawings of items 1 and 6.

Example 132.—Trace the drawing made in Example 131.

PLATE No. 74



DETAILS OF BED, ETC., FOR SHELL-ENDING LATHE

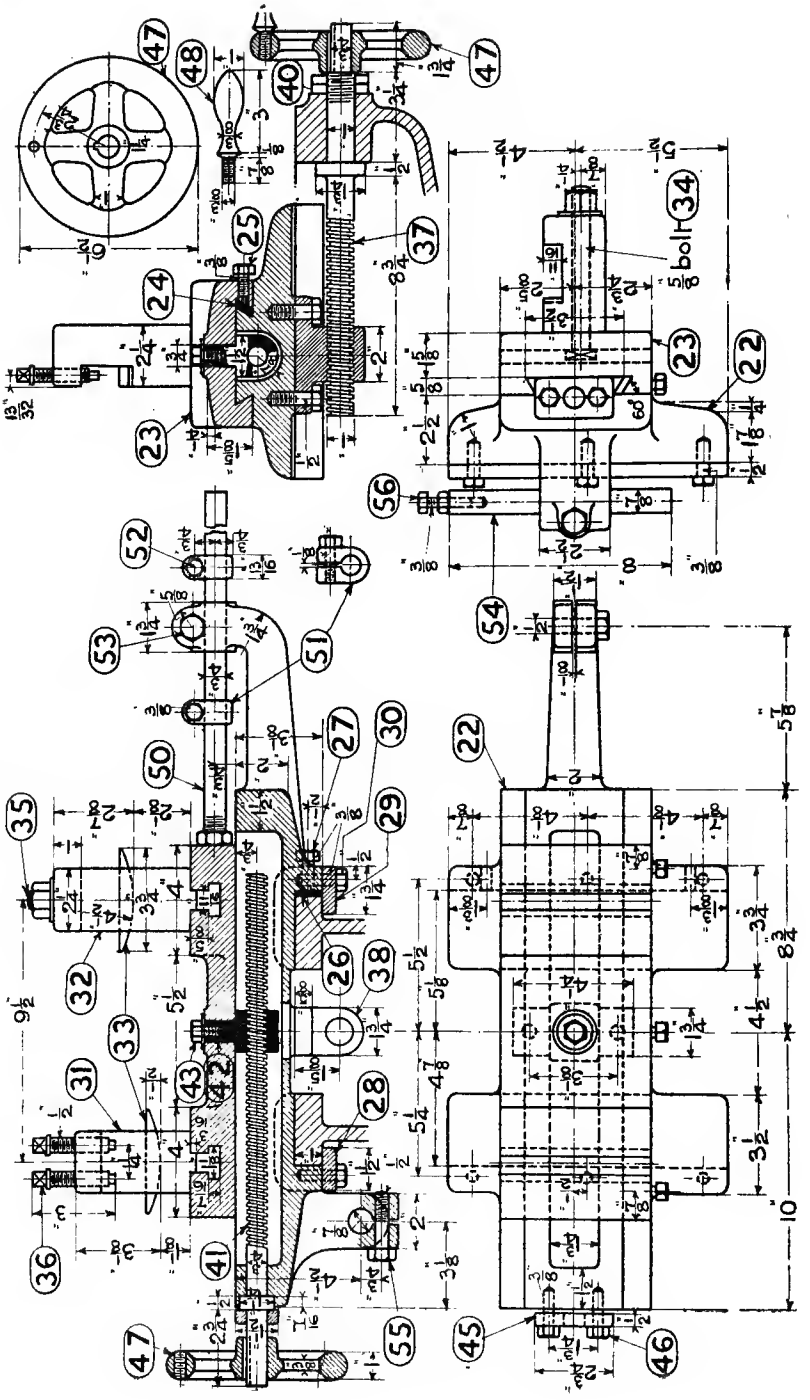
Reperence Number.	Description.	Material.	Number Required.	Pattern No. or Size.
12	Bed	Cast Iron	1	106
13	Maiu Bearing Cap	,,	1	107
14	Hex. Hd. Set Bolts	Mild Steel	2	$\frac{5}{8}$" × $3\frac{3}{4}$"
15	Tail Bearing Cap	Cast Iron	1	108
16	Hex. Hd. Set Bolts	Mild Steel	2	$\frac{1}{2}$" × $2\frac{1}{2}$"
17	Countershaft Bearing Cap	Cast Iron	2	109
18	Hex. Hd. Set Bolts	Mild Steel	4	$\frac{1}{2}$" × 2"
19	Eccentric Bush	Cast Iron	1	110
20	Oil Caps for Bearing Caps	,,	4	111
21	Spring Plunger for Eccentric Bush	Mild Steel	1	$\frac{7}{16}$" dia. $\frac{3}{4}$" long
21A	Spring for Plunger	Steel Wire	1	$\frac{7}{16}$" outs. dia.
21B	Grub Screw for Fixing Plunger	Mild Steel	1	$\frac{5}{8}$" dia. $\frac{1}{2}$" long
21C	Necessary Chain for Bearings	—	—	—

Example 133.—Make a drawing of the Bed complete, with all items given in list in their proper working positions.

Show the front elevation as a section, taking the section on line AB. The two end elevations and the plan are to be outside views.

To be drawn to a scale of $\frac{1}{4}$.

PLATE No. 75

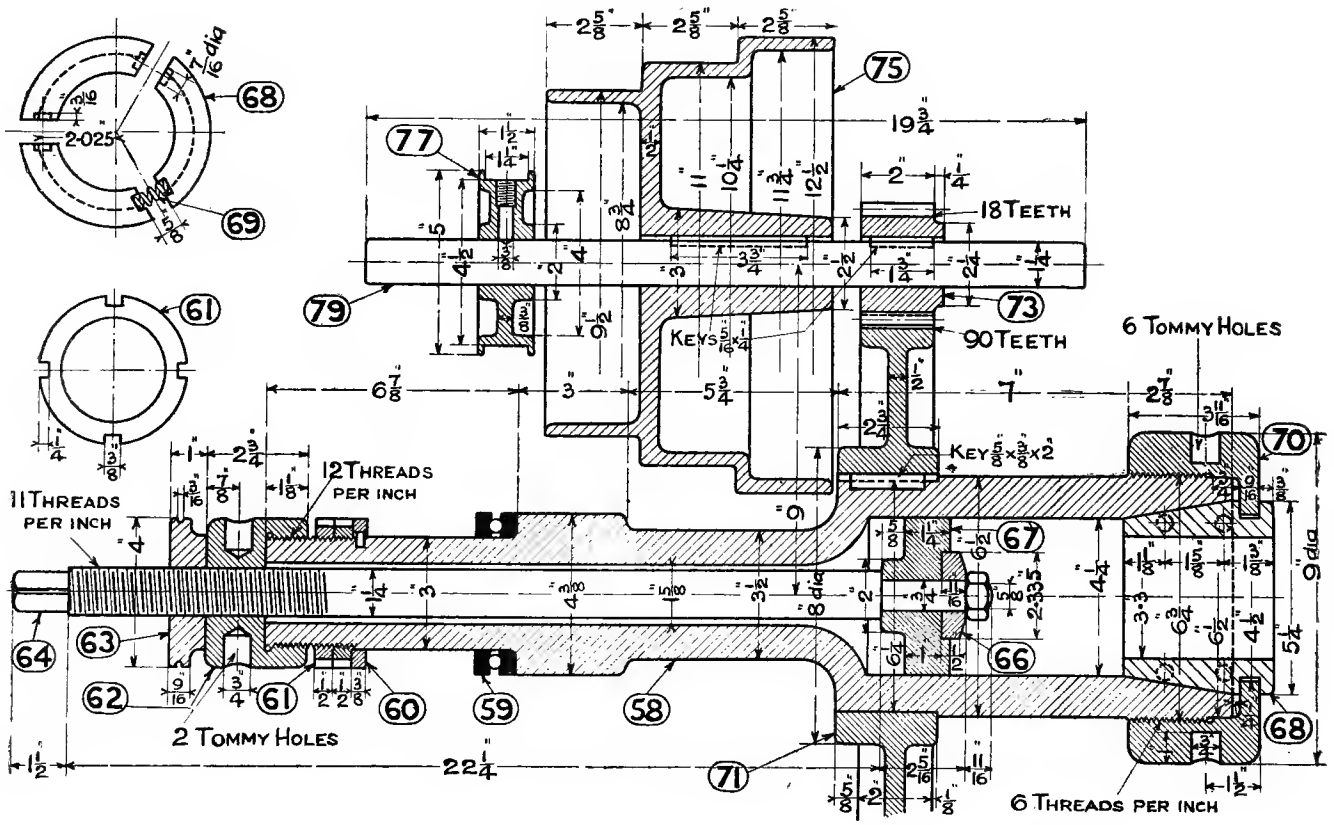


DETAILS OF SADDLE FOR SHELL-ENDING LATHE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
22	Saddle	Cast Iron	1	112
23	Slide	,,	1	113
24	Adjusting Strip for Slide	Bright Drawn Steel	1	$\frac{5}{8}$″ × $\frac{1}{4}$″ × 18″
25	Hex. Hd. Set Screws for Adjusting Strip for Slide	Mild Steel	3	$\frac{3}{8}$″ × 1$\frac{1}{4}$″
26	Adjusting Strip for Saddle	Bright Drawn Steel	1	1″ × $\frac{1}{4}$″ × 10″
27	Hex. Hd. Set Screws for Adjusting Strip for Saddle	Mild Steel	2	$\frac{3}{8}$″ × 1$\frac{1}{8}$″
28	Front Strip for Saddle	Bright Drawn Steel	1	1$\frac{1}{2}$″ × $\frac{1}{2}$″ × 10″
29	Back ,, ,,	,,	1	1$\frac{1}{2}$″ × $\frac{1}{2}$″ × 10″
30	Hex. Hd. Set Screws for Back Strip for Saddle	Mild Steel	6	$\frac{3}{8}$″ × 1$\frac{1}{8}$″
31	Front Tool Post	Bright Drawn Steel	1	4$\frac{1}{2}$″ × 2$\frac{1}{4}$″ × 2$\frac{1}{4}$″
32	Back ,, ,,	,,	1	5$\frac{1}{4}$″ × 2$\frac{1}{4}$″ × 2$\frac{1}{4}$″
33	Tool Pads	Hardened Mild Steel	2	3$\frac{3}{4}$″ × 1$\frac{1}{8}$″ × $\frac{1}{2}$″
34	Sq'h'd Bolt for Front Tool Post	Mild Steel	1	$\frac{5}{8}$″ × 5$\frac{3}{4}$″, head $\frac{3}{8}$″ thick
35	,, ,, Back Tool Post	,,	1	$\frac{5}{8}$″ × 6$\frac{1}{2}$″, head $\frac{3}{8}$″ thick
36	,, Set Screws for Fixing Tools	,,	4	$\frac{1}{2}$″ × 3″
37	Saddle Screw	Bright Drawn Steel	1	14$\frac{1}{4}$″ long
38	Nut for Saddle Screw	Gun Metal	1	114
39	Hex. Hd. Set Bolts for Fixing Nut	Mild Steel	2	$\frac{1}{2}$″ × 1$\frac{1}{4}$″
40	Lock Nuts for Saddle Screw (11 threads per inch)	Mild Steel	2	2″ dia. $\frac{5}{16}$″ thick, tapped 1″ dia.
41	Traversing Screw for Slide (screwed 5 threads per inch for 13″)	Bright Drawn Steel	1	18$\frac{1}{2}$″ long
42	Nut for Traversing Screw for Slide	Gun Metal	1	115
43	Hex. Hd. Locking Screw for Nut	Mild Steel	1	$\frac{3}{8}$″ × $\frac{5}{8}$″
44	Washer for Hex. Hd. Locking Screw	,,	1	1$\frac{1}{4}$″ dia. $\frac{1}{8}$″ thick
45	Keep Plate for Traversing Screw	Wro't Iron	1	2$\frac{3}{4}$″ × 1$\frac{1}{4}$″ × $\frac{1}{4}$″
46	Hex. Hd. Set Bolts for Keep Plate for Traversing Screw	Mild Steel	2	$\frac{3}{8}$″ × 1$\frac{1}{4}$″
47	Hand Wheels	Cast Iron	2	116
48	Handles for Hand Wheels	Bright Drawn Steel	2	1″ dia. 4″ long
49	Keys for Hand Wheels	Key Steel	2	$\frac{5}{16}$″ × $\frac{1}{4}$″ × 1$\frac{1}{4}$″
50	Stop Rod for Slide	Bright Drawn Steel	1	$\frac{3}{4}$″ dia. × 14$\frac{1}{2}$″ long
51	,, Dogs	Mild Steel	2	—
52	Hex. Hd. Set Bolts for Dogs	,,	2	$\frac{3}{8}$″ × 1$\frac{1}{2}$″
53	,, Clamping Screw	,,	1	$\frac{1}{2}$″ × 1$\frac{1}{2}$″
54	Stop Rod for Saddle	Bright Drawn Steel	1	$\frac{7}{8}$″ dia. 8″ long
55	Hex. Hd. Clamping Screw	Mild Steel	1	$\frac{1}{2}$″ × 2″
56	,, Adjusting Screw for Stop Rod	,,	1	$\frac{5}{8}$″ × 1$\frac{1}{2}$″
57	Hex. Hd. Lock Nut	,,	1	$\frac{3}{8}$″

EXAMPLE 134.—Make separate detail working drawings of each of the following items: **22**, **23**, **31**, **37**, **38**, and **47**. Items **22** and **23** are to be drawn half full size and the remaining items full size.

PLATE No. 76


68
69
2·025
61
75
77
79
73
18 TEETH
90 TEETH
KEYS
6 TOMMY HOLES
KEY
70
67
66
64
63
62
61
60
59
58
71
68
11 THREADS PER INCH
12 THREADS PER INCH
2 TOMMY HOLES
6 THREADS PER INCH
9 dia
8 dia

DETAILS OF SPINDLE, CHUCK, AND DRIVING GEAR FOR SHELL-ENDING LATHE

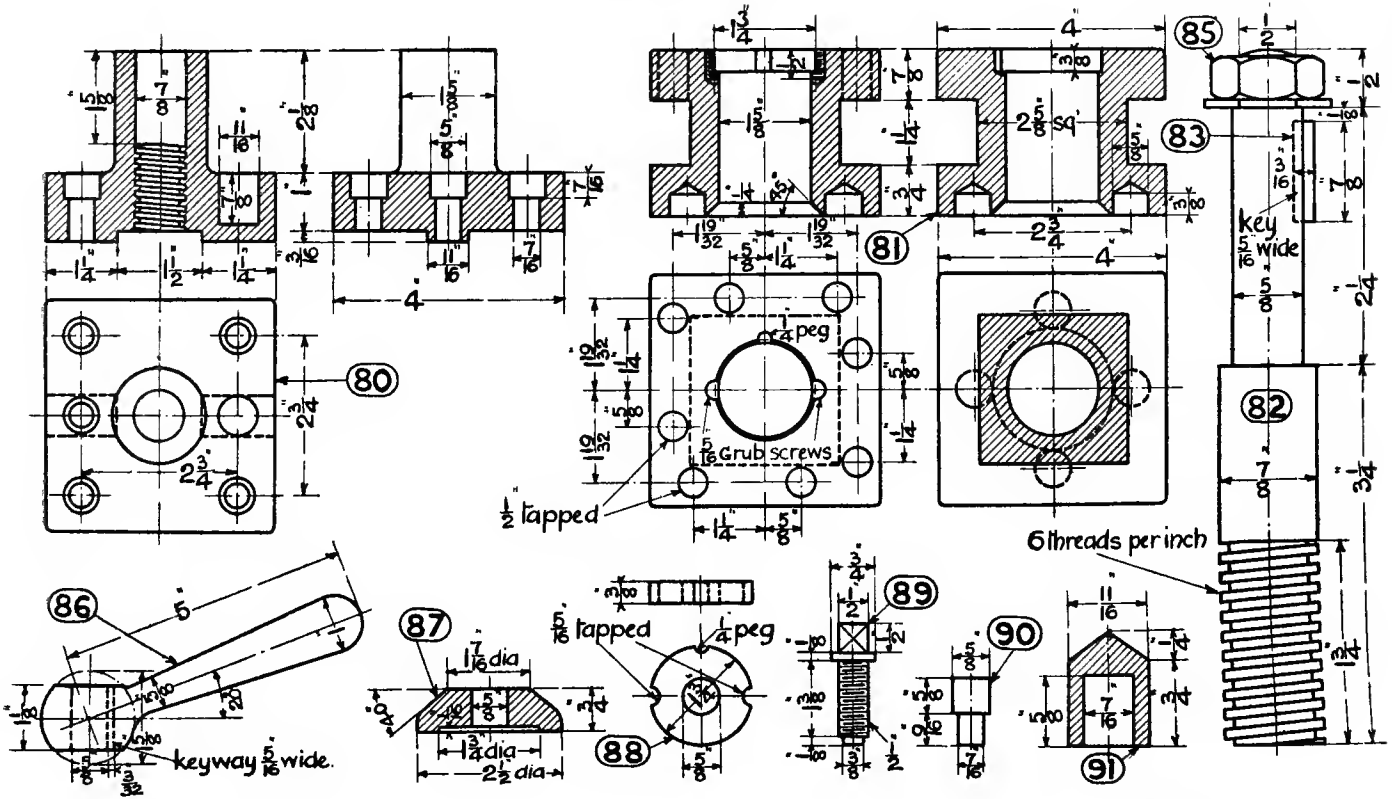
Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
58	Main Spindle	Cast Iron	1	117
59	Ball Thrust Washers	Hdnd. Steel	1 set	—
60	Washer for Lock Nuts	Mild Steel	1	4″ dia. $\frac{3}{8}$″ thick
61	Lock Nuts	,,	2	4″ dia. $\frac{1}{2}$″ thick
62	Thrust Block	Cast Iron	1	118
63	Adjusting Nut	Hardened Mild Steel	1	4″ dia. 1″ thick
64	,, Screw	Bright Drawn Steel	1	$1\frac{1}{4}$″ dia. $26\frac{3}{4}$″ long
65	Hex. Nut for Screw	Mild Steel	1	$\frac{5}{8}$″
66	Centraliser	Hardened Mild Steel	1	$2\frac{3}{8}$″ dia. × $1\frac{1}{16}$″ thick
67	,, Bearing	Cast Iron	1	119
68	Collet (in 3 segments)	Hardened Mild Steel	1	—

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
69	Springs for Collet	Spring Steel	6	$\frac{7}{16}$″ dia. 1″ long
70	Cap ,, ,,	Hardened Mild Steel	1	9″ dia. $3\frac{1}{16}$″ thick
71	Gear Wheel	Cast Iron	1	90 teeth, 6s d.p.
72	Key for Gear Wheel	Key Steel	1	$\frac{5}{8}$″ × $\frac{3}{8}$″ × 2″
73	Pinion	Mild Steel	1	18 teeth, 6s d.p.
74	Key for Pinion	Key Steel	1	$\frac{5}{16}$″ × $\frac{1}{4}$″ × $1\frac{3}{4}$″
75	Cone Pulley	Cast Iron	1	120
76	Key for Cone Pulley	Key Steel	1	$\frac{5}{16}$″ × $\frac{1}{4}$″ × $3\frac{3}{4}$″
77	Pulley for Driving Oil Pump	Cast Iron	1	121
78	Set Screw for Pulley for Driving Oil Pump	Mild Steel	1	$\frac{1}{4}$″ × $1\frac{5}{8}$″
79	Shaft for Cone Pulley	,,	1	$1\frac{1}{4}$″ dia. $19\frac{3}{4}$″ long

Example 135.—Make separate detail working drawings of each of the following items: **58, 62, 68, 70,** and **75**. To be drawn to a scale of 6″ = 1′.

Example 136.—Trace the drawing made in Example 135.

PLATE No. 77

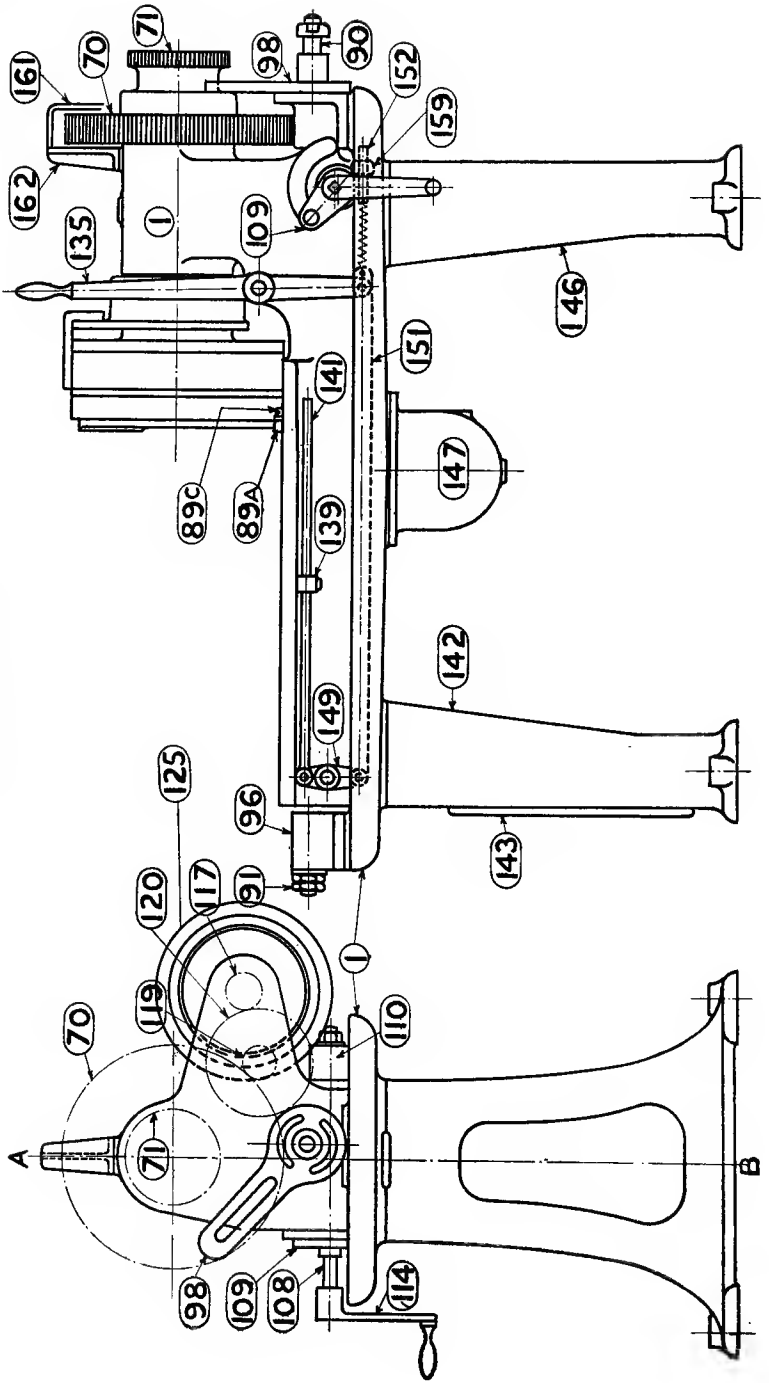

80
81
82
83
85
86
87
88
89
90
91
4
2 3/4
2 5/8 sq.
key 5/16 wide
1/4 peg
5/16 Grub screws
1/2 tapped
6 threads per inch
keyway 5/16 wide.
1 7/16 dia
3/4 dia
2 1/2 dia
5/16 tapped
1/4 peg

SQUARE TURRET FOR LATHE

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
80	Base	Cast Steel	1	—
81	Turret . .	,,	1	—
82	Locking Screw .	Bright Drawn Steel	1	—
83	Key for Locking Screw . .	Key Steel	1	$\frac{5}{16}$" × $\frac{3}{16}$" × $\frac{1}{8}$"
84	Washer for Locking Screw	Mild Steel	1	$\frac{1}{2}$"
85	Hex. Lock Nut	,,	1	$\frac{1}{2}$"
86	Handle for Locking Screw . .	,,	1	—
87	Special Washer	,,	1	$2\frac{1}{2}$" dia. $\frac{3}{4}$" thick
88	Pressure Plate	,,	1	$1\frac{3}{4}$" dia. $\frac{3}{8}$" thick
89	Screws for Fixing Tools . . .	,,	8	$\frac{1}{2}$" × $2\frac{1}{2}$"
90	Positioning Peg .	Bright Drawn Steel	1	$\frac{5}{8}$" × $1\frac{3}{16}$"
91	Plunger for Spring . . .	Mild Steel	1	$\frac{1}{16}$" dia. × 1" long
92	Helical Spring	Spring Steel	1	—

Example 137.—Make a drawing, scale full size, showing all the parts assembled together in their correct working positions. Show two elevations and a plan, one elevation being a section through centre of turret.

PLATE No. 78


71
70
161
162
135
98
90
152
159
109
146
151
141
147
89C
89A
139
142
149
125
96
143
91
120
117
119
110
70
71
98
109
108
114
A
B

PIPE-SCREWING MACHINE

Plate No. 76 shows two incomplete elevations of a Pipe-screwing Machine suitable for dealing with pipes up to 4″ diameter. Most of the detail working drawings of this machine are given on Plates Nos. 79 to 87 inclusive.

The machine was specially designed for use in shipyards where accurate work to Admiralty requirements is required, and where it is frequently necessary to bend pipes before they are screwed.

The die head and spindle of the machine are hollow, allowing pipes of any length to be screwed.

The vice is arranged to swivel and to set out of centre, so that irregular shaped pipes and bends can be held central with the dies.

The dies are of the adjustable chaser type, working on cams, and can be released automatically, or by hand, when the required length of screwing has been done.

The die head is fitted with a patent arrangement for screwing taper or vanishing threads with the ordinary dies.

A turning head is supplied for turning pipes exact to size before the screwing operation is carried out. After being turned, the pipe is simply moved forward into the dies for screwing.

The saddle is traversed along the bed by means of a machine-cut pinion and rack.

A self-feeding cutting off apparatus is fitted for ending off the pipes clean and square.

The machine is belt-driven, a three-speed cone being provided for the purpose.

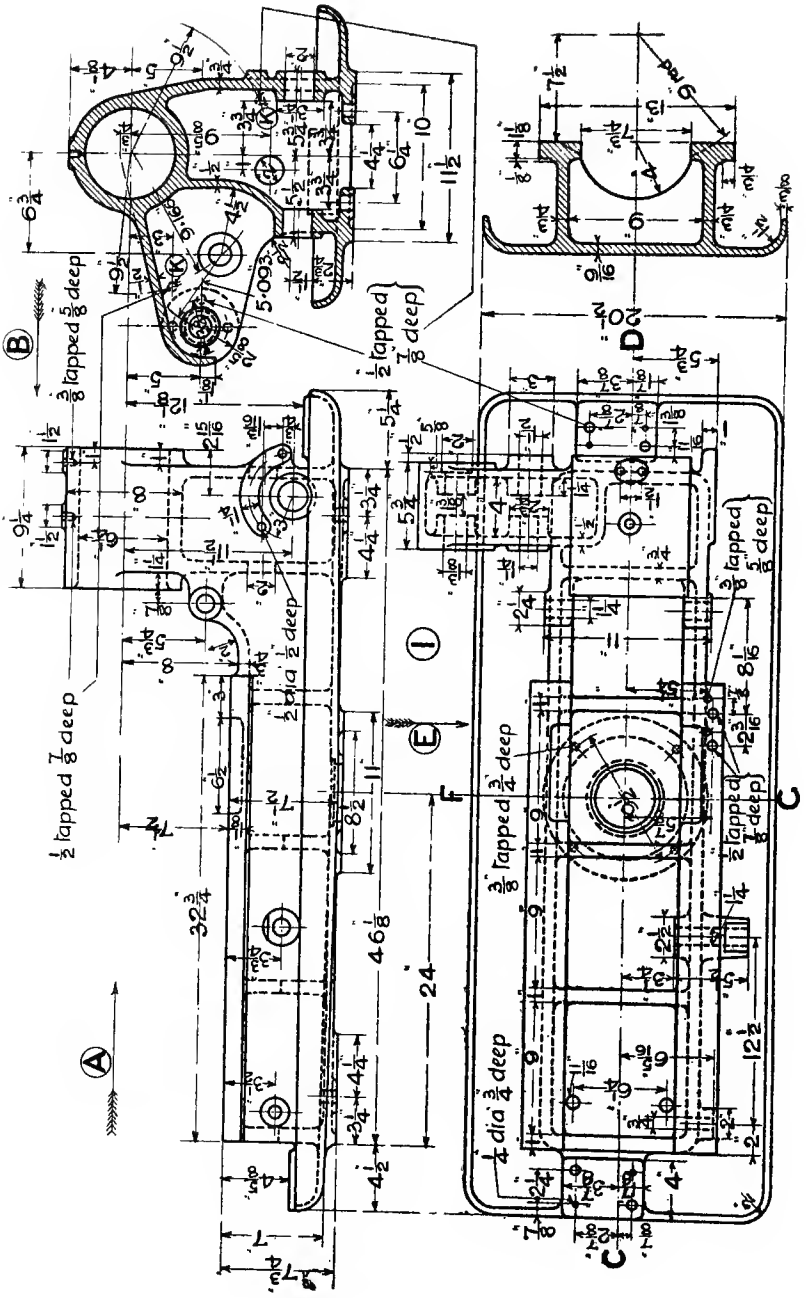
Lubricant for the dies is supplied by a geared pump, which is not shown in the illustrations.

EXAMPLE 138.—Make a complete general arrangement of the machine to a scale af 3″ = 1′. Show the two elevations (but to be complete views), and add as much of the plan as can conveniently be shown. The plan view must include the whole of the driving gear details.

NOTE.—The gear guard is merely suggested in the illustration, and the design of the guard is called for in Example 140 on the following page.

The latter Example should, therefore, precede the making of the general arrangement drawing, so that the gear guard can be embodied.

PLATE No. 79


A
B
C
D
E
F
I
24"
46⅛"
32¾"
5·093"
½ tapped ⅞ deep
⅜ tapped ⅝ deep
¾ tapped ¾ deep
½ dia ½ deep
¼ dia ¾ deep

PIPE-SCREWING MACHINE BED

An elevation, a plan, and two sectional end views of the Cast-iron Bed for the Pipe-screwing Machine are given on this plate.

Besides forming the bed of the machine, the bearing carrying the spindle or mandrel is an integral part of the casting.

The housing for some of the driving gears and an oil tray are also embodied in the one casting.

The two sectional end elevations are taken looking in the direction of arrow **A**.

EXAMPLE 139.—Make a working drawing of the bed, giving the following views :—

(1) A longitudinal sectional elevation, taking the section on the centre line **CD**, looking in the direction indicated by the arrow **E**.
(2) A plan projected under view (1).
(3) A sectional end elevation, the section being taken on a stepped line passing through the vertical centre of the head and the housing for the gears, looking in the direction indicated by arrow **B**.
(4) A sectional end elevation on line **FG**, looking in the direction of arrow **A**.

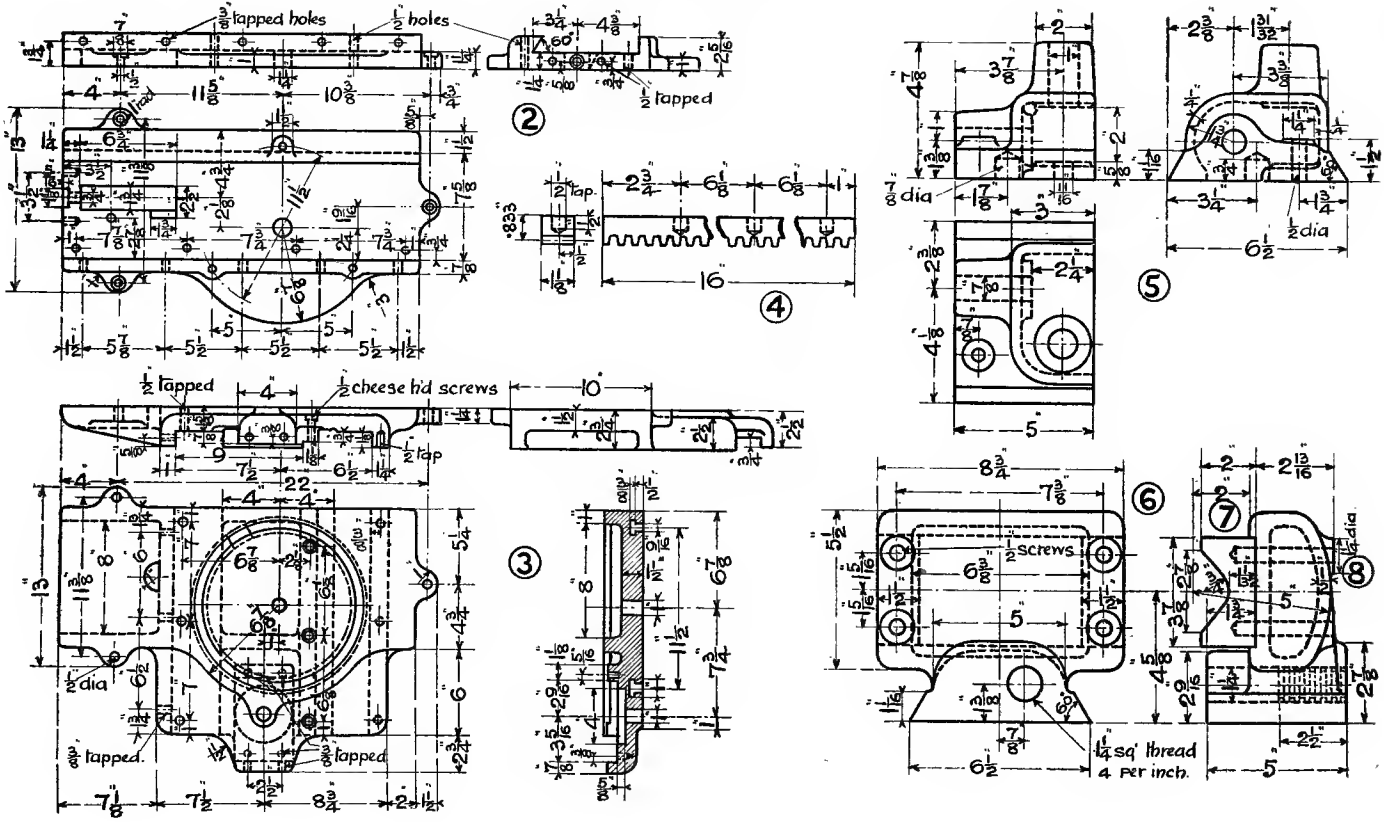
EXAMPLE 140.—Make a drawing to as large a scale as your paper permits, showing the arrangement of the driving gear, and as much of the bed and housing as is required to show how the gearing is carried. Show a side elevation, an end elevation, and a plan. The side elevation should be one looking in the direction indicated by arrow **E**, and the end elevation looking in direction of arrow **B**.

Details of the driving gear will be found on Plates Nos. 83, 85, and 86.

A suitable gear guard is to be designed and shown on this drawing.

This guard and bracket are suggested in the illustration on Plate No. 78 (items numbered **161** and **162**). The two $\frac{1}{2}''$ tapped holes marked (**K**) in the sectional end view of the bed are for set screws for fixing the guard.

PLATE No. 80


tapped holes
holes
tapped
cheese hd screws
screws
sq' thread
4 per inch.
dia
tap

DETAILS OF SWIVEL SADDLE AND VICE

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
2	Saddle Swivelling Plate .	Cast Iron	1	1841
3	,, Base Plate . .	,,	1	1842
4	Rack (6s diametral pitch) .	Mild Steel	1	—
5	Housing for Worm and Wheel	Cast Iron	1	1843
6	Vice Jaws . .	,,	2	—
7	Pipe Grips	Hardened Cast Steel	4	—
8	Hex. Hd. Set Bolts . . .	Mild Steel	8	$\frac{1}{2}''$ × $3\frac{3}{4}''$
8A	Ch. Hd. Set Screws for Rack .	,,	3	$\frac{1}{2}''$ × $2\frac{1}{4}''$

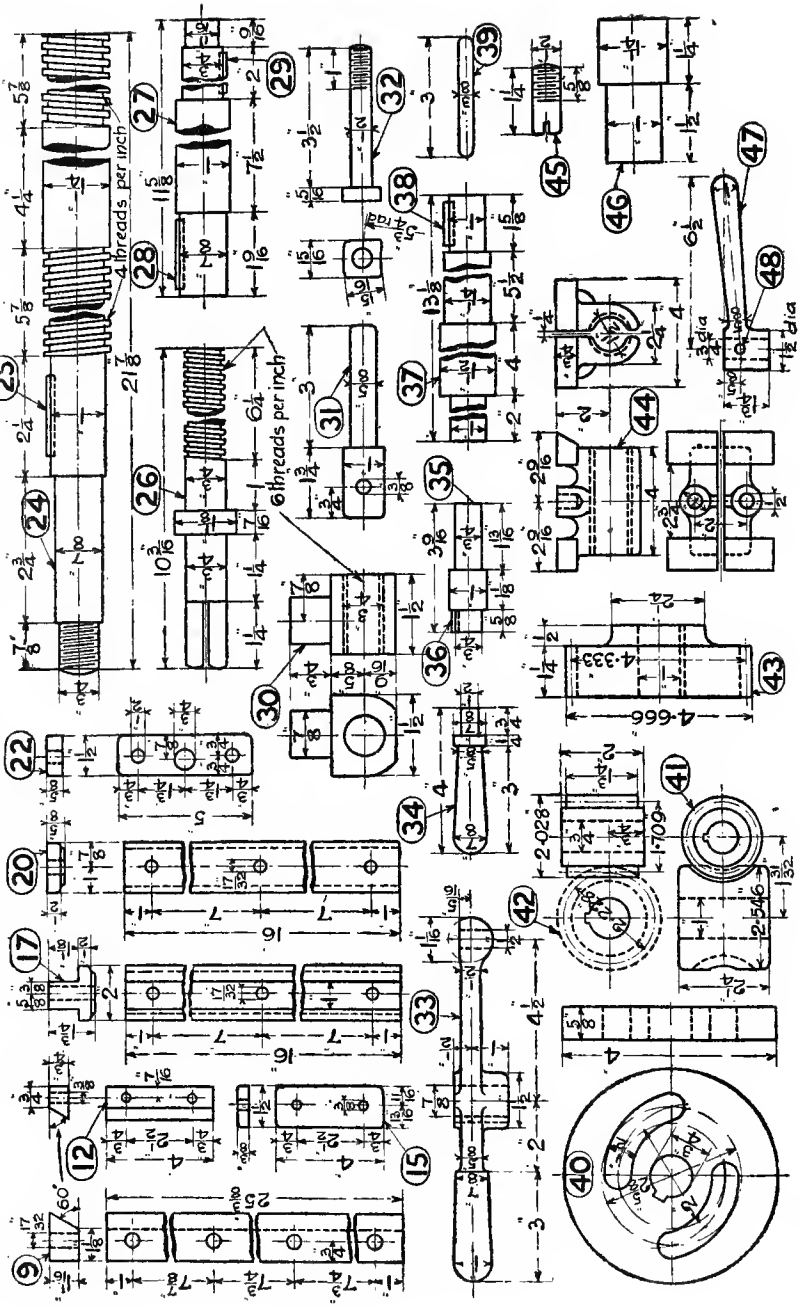
Some details of the Swivel Saddle and Vice for the Pipe-screwing Machine are shown in the illustration above. Other details appear on Plate No. 81, and a general assembly is shown on Plate No. 82.

Example 141.—Make a drawing (scale, full size) showing two sectional elevations and a plan of the housing for the worm and wheel (item 5). Show the worm and wheel, with their respective spindles, in their correct working positions.

Details of the worm, wheel, and spindles are given on Plate No. 81 (items **25, 27, 28, 29, 41,** and **42,** and a portion of item **24**).

The other details of the saddle, etc., illustrated above are to be embodied in the assembly drawing called for in the text accompanying Plate No. 82.

PLATE No. 81


4 threads per inch
6 threads per inch
60°
4.666
4.333
2.028
.709
2.546

DETAILS OF SWIVEL SADDLE AND VICE

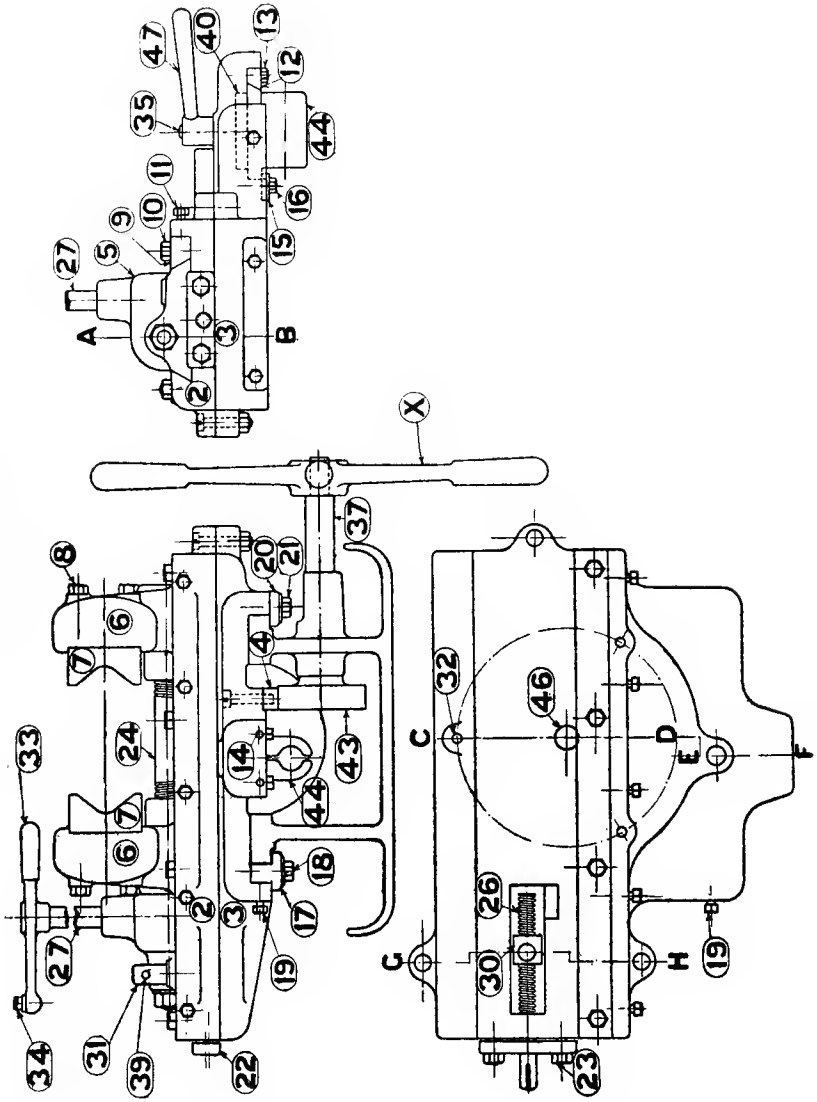
Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
9	Adjusting Strip for Vice . .	Mild Steel	1	$1\frac{3}{4}'' \times 1\frac{1}{16}'' \times 25\frac{3}{8}''$
10	Hex. Hd. Set Bolts for Adjusting Strip		4	$\frac{1}{2}'' \times 1\frac{3}{4}''$
11	Hex. Hd. Adjusting Screws for Adjustiog Strip		5	$\frac{3}{8}'' \times 1\frac{1}{4}''$
12	Adjusting Strip for Lead Screw Nut	Cast Iron	1	1844
13	Hex. Hd. Set Bolts for Adjusting Strip for Lead Screw Nut	Mild Steel	2	$\frac{3}{8}'' \times 1\frac{1}{4}''$
14	Grub Screws for Adjusting item 12		2	$\frac{3}{8}'' \times \frac{7}{8}''$
15	Fixing Strip for Lead Screw Nut	,,	1	$1\frac{1}{2}'' \times \frac{3}{8}'' \times 4''$
16	Hex. Hd. Set Bolts for Fixing Strip for Lead Screw Nut	,,	2	$\frac{3}{8}'' \times 1''$
17	Adjusting Strip for Base Plate .	Cast Iron	1	1845
18	Hex. Hd. Set Bolts for Adjusting Strip for Base Plate	Mild Steel	3	$\frac{1}{2}'' \times 2\frac{1}{2}''$
19	Hex. Hd. Adjusting Screws for Item 17		3	$\frac{3}{8}'' \times 1\frac{3}{8}''$
20	Fixing Strip for Base Plate. .	Cast Iron	1	1846
21	Hex. Hd. Set Bolts for Fixing Strip for Base Plate. . .	Mild Steel	3	$\frac{1}{2}'' \times 1\frac{3}{8}''$
22	Keep Plate for Leading Screw .	,,	1	$1\frac{1}{2}'' \times \frac{5}{8}'' \times 5''$
23	Hex. Hd. Set Bolts for Keep Plate for Leading Screw .	,,	2	$\frac{1}{2}'' \times 1\frac{1}{8}''$
24	Saddle Screw	Bright Drawn Steel	1	$1\frac{1}{4}''$ dia. 22" long
25	Feather Key for Worm Wheel .	Key Steel	1	$\frac{1}{4}'' \times \frac{3}{16}'' \times 1\frac{3}{4}''$
26	Adjusting Screw for Vice . .	Mild Steel	1	—

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
27	Worm Spindle	Bright Drawn Steel	1	1" dia. $11\frac{5}{8}$" long
28	Key for Worm Spindle (for worm)	Key Steel	1	$\frac{3}{16}'' \times \frac{1}{2}'' \times 1\frac{1}{2}''$
29	,, ,, ,, (for lever)	,,	1	$\frac{3}{16}'' \times \frac{3}{8}'' \times 1\frac{1}{2}$
30	Nut for Vice Adjusting Screw .	Mild Steel	1	—
31	Positioning Peg for Vice . .	Bright Drawn Steel	1	1" dia. $4\frac{3}{4}$" long
32	Special Bolts with Hex. Nuts for Swivelling Plate	,,	3	$\frac{1}{2}'' \times 3\frac{1}{2}''$
33	Lever for Worm Spindle . .	Malleable Cast Iron	1	1846
34	Handle for Lever . . .	Bright Drawn Steel	1	$\frac{7}{8}''$ dia. 4" long
35	Cam Shaft	,,	1	1" dia. $3\frac{9}{16}$" long
36	Key for Cam Shaft . . .	Key Steel	1	$\frac{1}{4}'' \times \frac{1}{4}'' \times \frac{5}{8}''$
37	Shaft for Rack Pinion. . .	Bright Drawn Steel	1	$1\frac{1}{2}''$ dia. $13\frac{1}{8}$" long
38	Key for Shaft for Rack Pinion .	Key Steel	1	$\frac{1}{4}'' \times \frac{1}{4}'' \times 1\frac{1}{2}''$
39	Tommy Bar for Positioning Peg	Mild Steel	1	$\frac{3}{8}'' \times 3''$
40	Cam for Lead Screw Nut . .	Cast Iron	1	1847
41	Worm ($\frac{1}{2}$" pitch, r.h. thread) .	Mild Steel	1	—
42	,, Wheel ($\frac{1}{2}$" pitch, 14 teeth)	,,	1	—
43	Rack Pinion (6s diametral pitch).	,,	1	26 teeth
44	Nut for Lead Screw (in halves) .	Brass	1	1848
45	Pins for Nut	Bright Drawn Steel	2	$\frac{1}{2}'' \times 1\frac{1}{2}''$
46	Swivel Pin	,,	1	$1\frac{1}{4}''$ dia. $2\frac{3}{4}$" long
47	Cam Shaft Handle . . .	Mild Steel	1	—
48	Pin for Cam Shaft Handle . .	,,	1	$\frac{3}{16}'' \times 1\frac{1}{2}''$

As many of these details as possible are to be shown on the assembly drawing called for in the example accompanying Plate No. 82.

Details, **25**, **27**, **28**, **29**, **41**, and **42**, and part of **24**, are to be shown in the example called for on the preceding page.

PLATE No. 82



SWIVEL SADDLE AND VICE

Though incomplete, the views illustrated above of the Swivel Saddle, etc., for the Screwing Machine will enable the student to identify the working positions of the details shown on the two preceding plates.

EXAMPLE 142.—Draw two elevations and a plan of the saddle and vice, complete, corresponding to those shown on the plate, but to be as fellows :—

(*a*) Side elevation to be a section on line AB.

(*b*) End elevation to be a section on line CDEF.

(*c*) A plan.

NOTE.—Any part whose shape is entirely shown by the two elevations may be omitted from the plan. Otherwise the plan is to be as complete as possible.

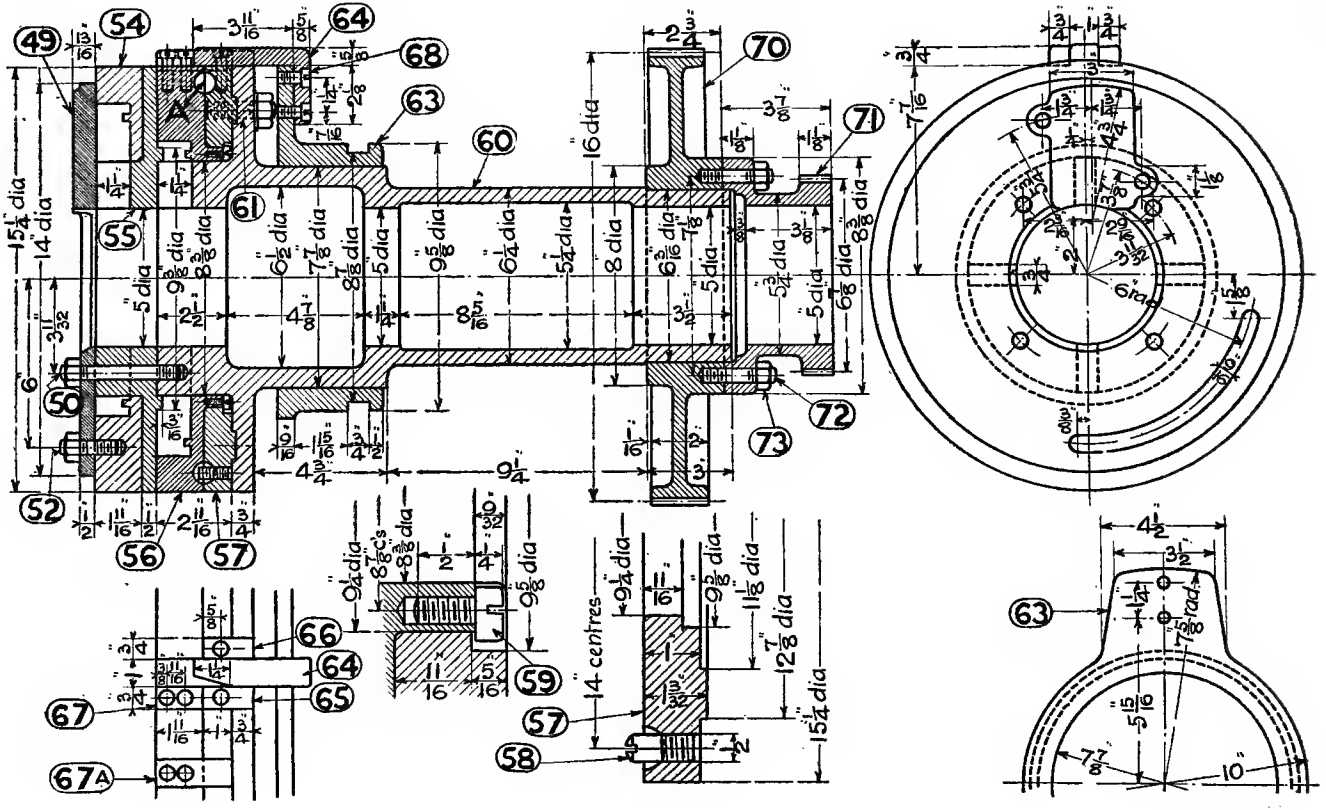
(*d*) To the right of the plan project a sectional elevation, taking the section approximately on the line GH, but including a section through the worm gear housing (item 5).

NOTE.—The knock-off bracket shown on Plate No 86 (item 137) is to be shown in position fixed to item 20.

To be drawn to as large a scale as the drawing paper will permit.

EXAMPLE 143.—Make a working drawing of the star wheel X. This is not shown on any of the detail plates, but may be scaled from the illustration. There are four arms, and the material may be malleable cast iron. The wheel is keyed to the spindle.

PLATE No. 83


49
54
64
68
63
60
70
71
61
55
50
52
56
57
72
73
66
65
67
67A
59
58
14 centres
63

TURNING HEAD FOR PIPE-SCREWING MACHINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
49	Front Plate	Cast Iron	1	1849
50	Studs for Front Plate (screwed $\frac{3}{4}$″ each end)	Mild Steel	4	$\frac{1}{2}$″ × 4″
51	Hex. Nuts for Studs for Front Plate	,,	4	$\frac{1}{2}$″
52	Locking Stud (screwed $\frac{3}{4}$″ each end)	,,	1	$\frac{1}{2}$″ × 1$\frac{3}{4}$″
53	Hex. Nut for Locking Stud	,,	1	$\frac{1}{2}$″
54	Tool Holder (cam) . .	Cast Iron	1	1850
55	Back Plate	,,	1	1851
56	Die Holder (cam) .	,,	1	1852
57	Spring Ring . .	,,	1	1853
58	,, Pins . . .	Mild Steel	4	$\frac{1}{4}$″ dia. 1$\frac{5}{8}$″ long
59	Ch. Hd. Checking Screws	,,	2	$\frac{1}{4}$″ dia. $\frac{1}{2}$″ long
60	Hollow Mandrel . . .	Cast Iron	1	1854
61	Locking Studs (screwed $\frac{5}{8}$″ at each end)	Mild Steel	2	$\frac{5}{8}$″ × 2$\frac{1}{4}$″
62	Hex. Nuts with Standard Washers	,,	2	$\frac{5}{8}$″

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
63	Sleeve	Cast Iron	1	1855
64	Former	Hdnd. Steel	1	—
65	,, Guide on Spring Ring, R.H.	,	1	—
66	Former Guide on Spring Ring, L.H.	,,	1	—
67	Stop on Die Holder, Short .	,,	1	—
67A	,, ,, ,, ,, Long	,,	1	—
68	Ch. Hd. Screws for Former .	Mild Steel	2	$\frac{3}{16}$″ × $\frac{7}{8}$″
69	,, ,, ,, ,, Guides and Stops	,,	6	$\frac{3}{16}$″ × 1″
70	Gear Wheel, 96 Teeth, 6s D.P.	Cast Iron	1	1856
71	,, ,, 55 Teeth, 8s D.P.	,,	1	1857
72	Studs for Fixing Gear Wheel (screwed $\frac{3}{4}$″ each end)	Mild Steel	2	$\frac{1}{2}$″ × 2$\frac{3}{8}$″
73	Hex. Nuts for Studs for Fixing Gear Wheel	,,	2	$\frac{1}{2}$″
73A	Helical Springs	Steel	2	—

Some of the details of the Turning Head for the Pipe-screwing Machine are illustrated on this plate.

There are four turning tools and four screwing dies, the former being fixed in the tool holder cam (**54**), and the latter in the die holder cam (**56**).

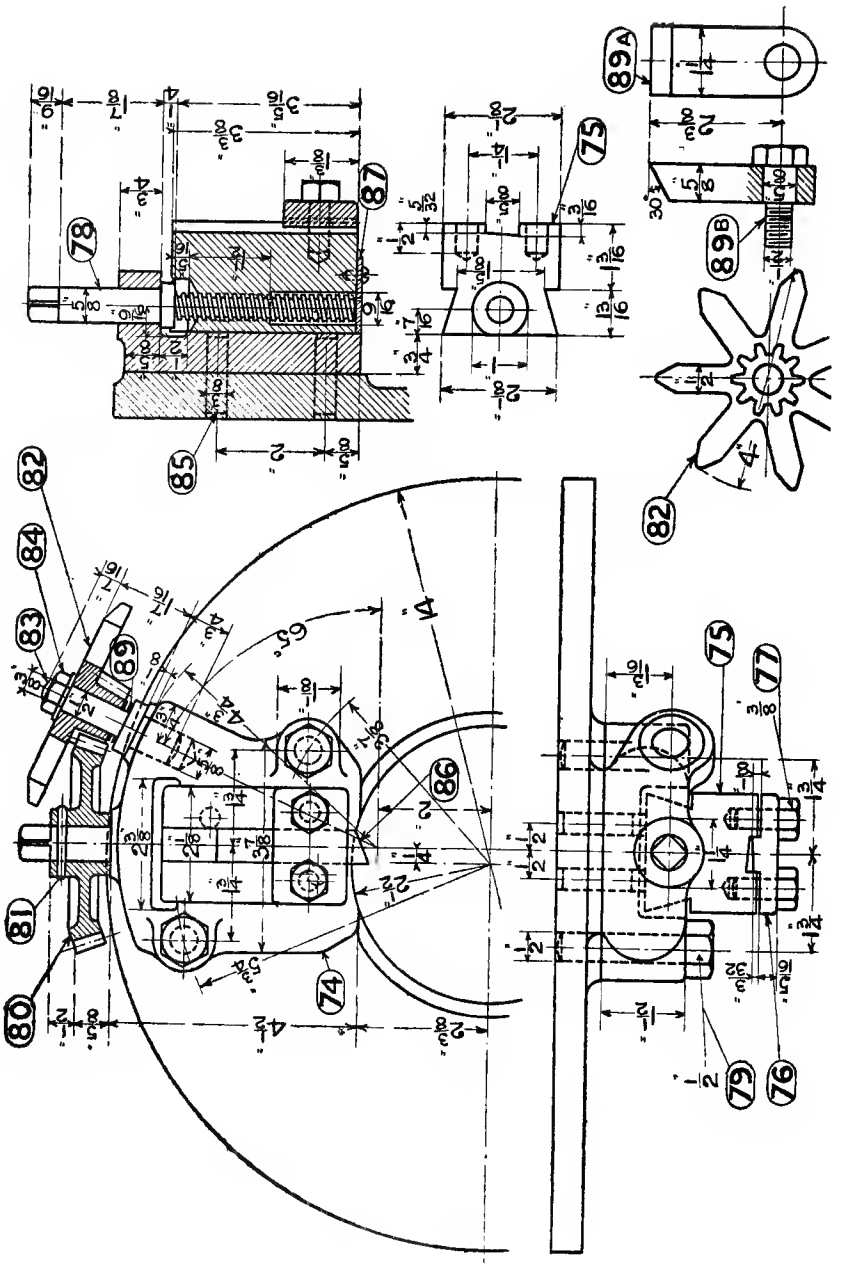
The cam faces are spiral in shape, so that the tools and dies may be advanced or withdrawn by simple rotary movement of the cams. Two long coiled springs lie in the groove A.

The spring ring (**57**) is locked to the flange of the mandrel (**60**) by means of two studs (**61**). There are four spring pins (**58**), two in the spring ring (**57**), and two in the die holder (**56**). The coiled springs have their ends butting against these pins, and give the opening motion when the former (**64**) is clear of the stop (**67**).

The two screws (**59**) prevent the springs from pushing the die holder from the spring ring when the front plate is removed to change the dies or tools.

Example 144.—Make detail working drawings of each of the following items: **49**, **60**, **63**, **70**, and **71**.

PLATE No. 84



HOLDER FOR CUTTING-OFF TOOL FOR PIPE-SCREWING MACHINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
74	Holder Bracket . .	Cast Iron	1	1858
75	,, Clip	,,	1	1859
76	,, ,, Cap	Mild Steel	1	—
77	Hex. Hd. Set Bolts for Cap .	,,	2	$\frac{3}{8}'' \times \frac{3}{4}''$
78	Adjusting Screw ($\frac{1}{2}''$ dia., screwed 7 threads per inch)	,,	1	Square threads
79	Hex. Hd. Set Bolts for Holder Bracket	,,	2	$\frac{1}{2}'' \times 2\frac{1}{4}''$
80	Bevel Wheel (32 teeth, $\frac{3}{8}''$ pitch)	Cast Iron	1	1860
81	Taper Pin for Bevel Wheel .	Mild Steel	1	$\frac{3}{16}'' \times 1\frac{1}{4}''$
82	Bevel Pinion and Star Wheel	Malleable Cast Iron	1	1861
83	Centre Stud for Bevel Pinion and Star Wheel	Mild Steel	1	—

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
84	Hex. Nut for Stud ($\frac{5}{16}''$ thick)	Mild Steel	1	$\frac{3}{8}''$
85	Positioning Pins for Holder Bracket	,,	2	$\frac{3}{8}'' \times 1\frac{1}{8}''$
86	Parting Tool	Tool Steel	1	—
87	Dust Cap	Brass	1	$1\frac{3}{8}'' \times 1'' \times \frac{1}{16}''$
88	Snap Head Screws . . .	,,	2	$\frac{3}{16}'' \times \frac{3}{8}''$
89	Spring Washer for Centre Stud	Spring Steel	1	$\frac{1}{2}''$ Thackray
89A	Pawl	Mild Steel	1	$3'' \times 1\frac{1}{4}'' \times \frac{5}{8}''$
89B	Hex. Hd. Set Bolt for Fixing Pawl	,,	1	—
89C	Cheese Hd. Screw for Steadying Pawl . . .	,,	1	$\frac{3}{8}'' \times \frac{1}{2}''$

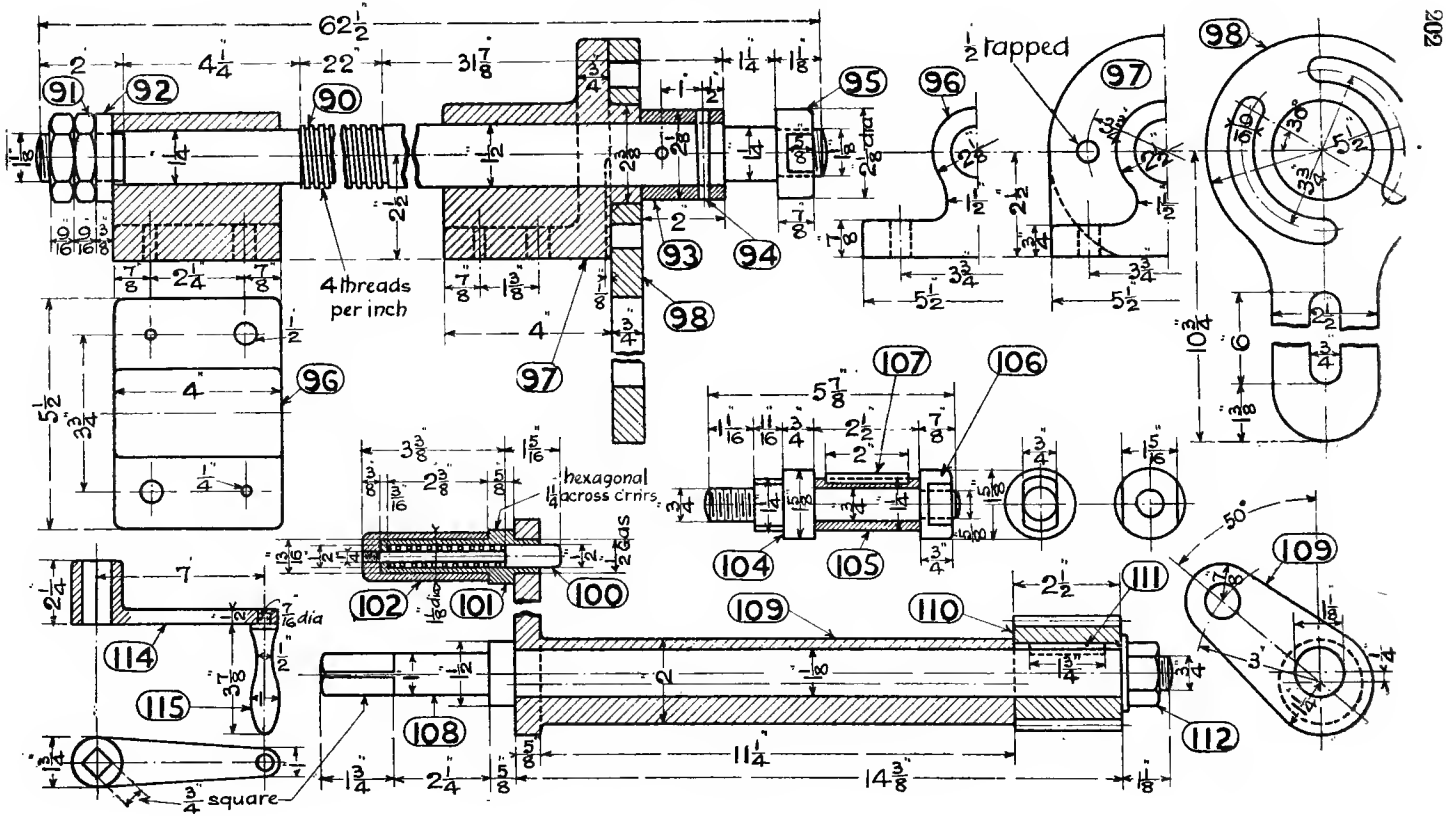
The Holder or Tool-box for the Cutting-off Tool of the Pipe-screwing Machine is illustrated on this plate.

The feed is self-acting through the agency of the bevel gear. A pawl (**89A**) is fixed to the front slide of the bed, and at each revolution of the turning head to which the tool holder is fixed one point of the star wheel strikes the pawl, so that, as there are seven points in the wheel, the pinion will make one complete turn for every seven revolutions of the head.

On the drawing of the bed there are shown two $\frac{1}{2}''$ and two $\frac{3}{8}''$ tapped holes in the front slide and near its right-hand end. The half inch holes are for the screw (**89B**) fixing the pawl. The $\frac{3}{8}''$ holes are for an ordinary cheese-head screw, the head of which butts up against the side of the pawl and takes the thrust when the star wheel comes into contact with the pawl. There are two positions for the pawl on the bed in case the cut off is required without the turning head being fixed to the die head.

Example 145.—Make full size detail working drawings of each of the following items: **74, 75, 78, 80, 82,** and **83.**

PLATE No. 85



LEADING SCREW, ETC., FOR PIPE-SCREWING MACHINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
90	Leading Screw	Mild Steel	1	1½″ dia. 62½″ long
91	Hex. Lock Nuts (5/16″ thick)	,,	2	1⅛″ tapped
92	Washer	,,	1	2¾″ dia. ⅜″ thick
93	Ferrule (1¼″ bore)	,,	1	2⅜″ dia. 2″ long
94	Taper Pins for Ferrule	,,	2	⅜″ dia. 2⅛″ long
95	Circular Nut	,,	1	1 7/16″ across flats
96	Left-hand Bearing for Leading Screw	Cast Iron	1	1862
97	Right-hand Bearing for Leading Screw	,,	1	1863
97A	Hex. Hd. Set Bolts for Bearings	Mild Steel	4	½″ × 1½″
98	Quadrant	Cast Iron	1	1864
99	Hex. Hd. Set Bolts for Quadrant	Mild Steel	2	½″ × 1⅜″
100	Spring Plunger	Bright Drawn Steel	1	—
101	,, ,, Sleeve	Mild Steel	1	—
102	,, ,, Cap (knurled on outside)	,,	1	—

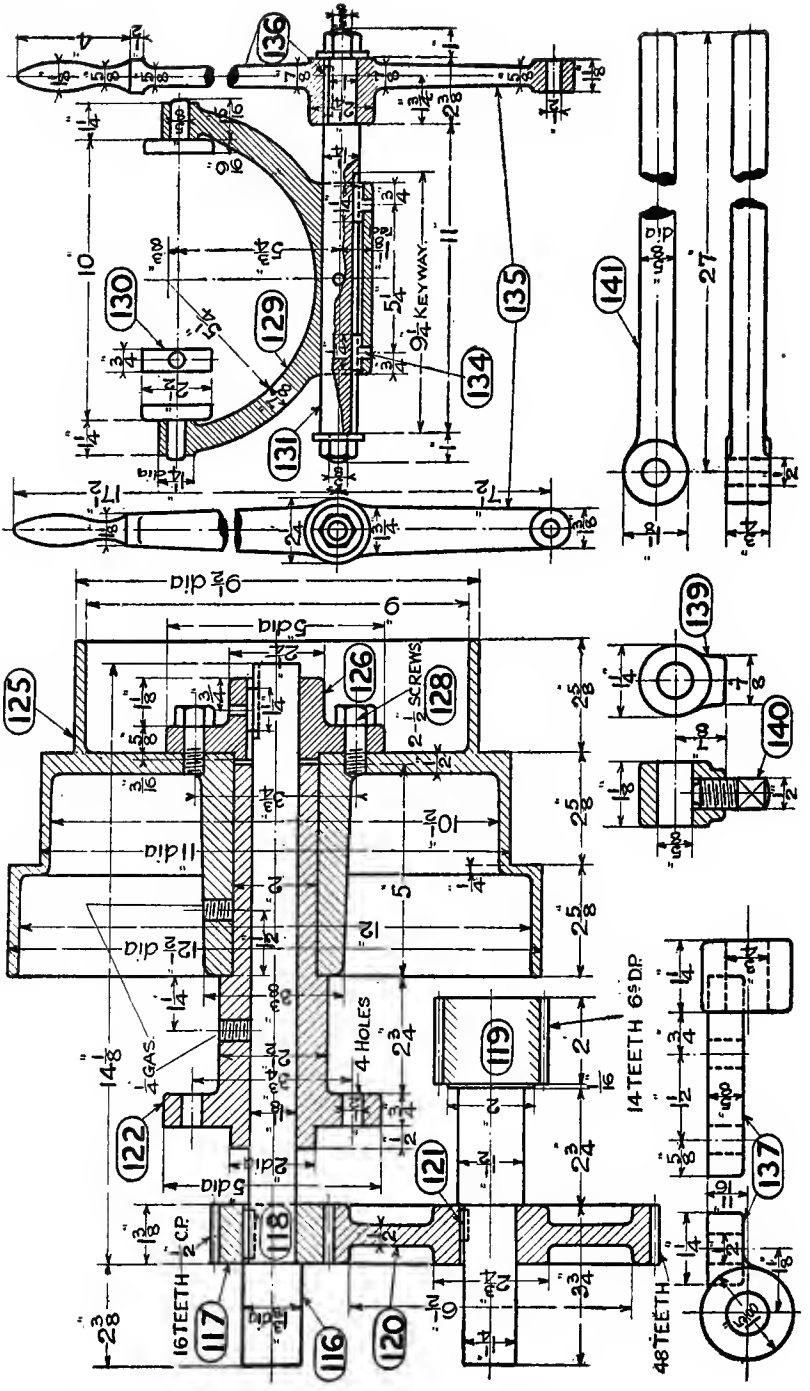
Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
103	Helical Spring	Spring Steel	1	—
104	Change Wheel Stud	Mild Steel	1	—
104A	Hex. Nut for Fixing Stud to Quadrant	,,	1	⅜″
105	Bush for Hex. Nut for Fixing Stud to Quadrant	,,	1	—
106	Nut for Bush (1 5/16″ across flats)	,,	1	—
107	Key for Bush	Key Steel	1	5/16″ × ¼″ × 2″
108	Shaft for Eccentric Sleeve	Bright Drawn Steel	1	—
109	Eccentric Sleeve	Cast Iron	1	1865
110	Worm, Left Hand (½″ pitch)	Mild Steel	1	2·44 p.c.d.
111	Key for Worm	Key Steel	1	5/16″ × ⅛″ × 1¾″
112	Hex. Nut for Eccentric Shaft	Mild Steel	1	⅜″
113	Washer for Hex. Nut for Eccentric Shaft		1	⅜″
114	Crank	,,	1	—
115	,, Handle	,,	1	1″ dia. 4⅜″ long
115A	Positioning Pegs for Bearings	,,	4	¼″ dia. 1⅜″ long
115B	Washer for Change Wheel Stud	,,	1	⅜″

Details of the Leading Screw and Bearings, Quadrant, etc., for the Pipe-screwing Machine are shown on the plate facing this page.

Example 146.—Make separate detail working drawings of each of the following items: **90**, **95**, **96**, **97** **98**,, **104**, **108**, and **109**.

Note.—All the details illustrated are to be included in the general arrangement drawing called for on page 189.

PLATE No. 86


136
135
134
131
130
129
141
KEYWAY.
125
126
128
139
140
127
119
122
121
118
117
116
120
137
4 HOLES
14 TEETH 6s D.P.
16 TEETH
48 TEETH
2-½ SCREWS
¼ GAS.

DETAILS OF DRIVING GEAR FOR PIPE-SCREWING MACHINE

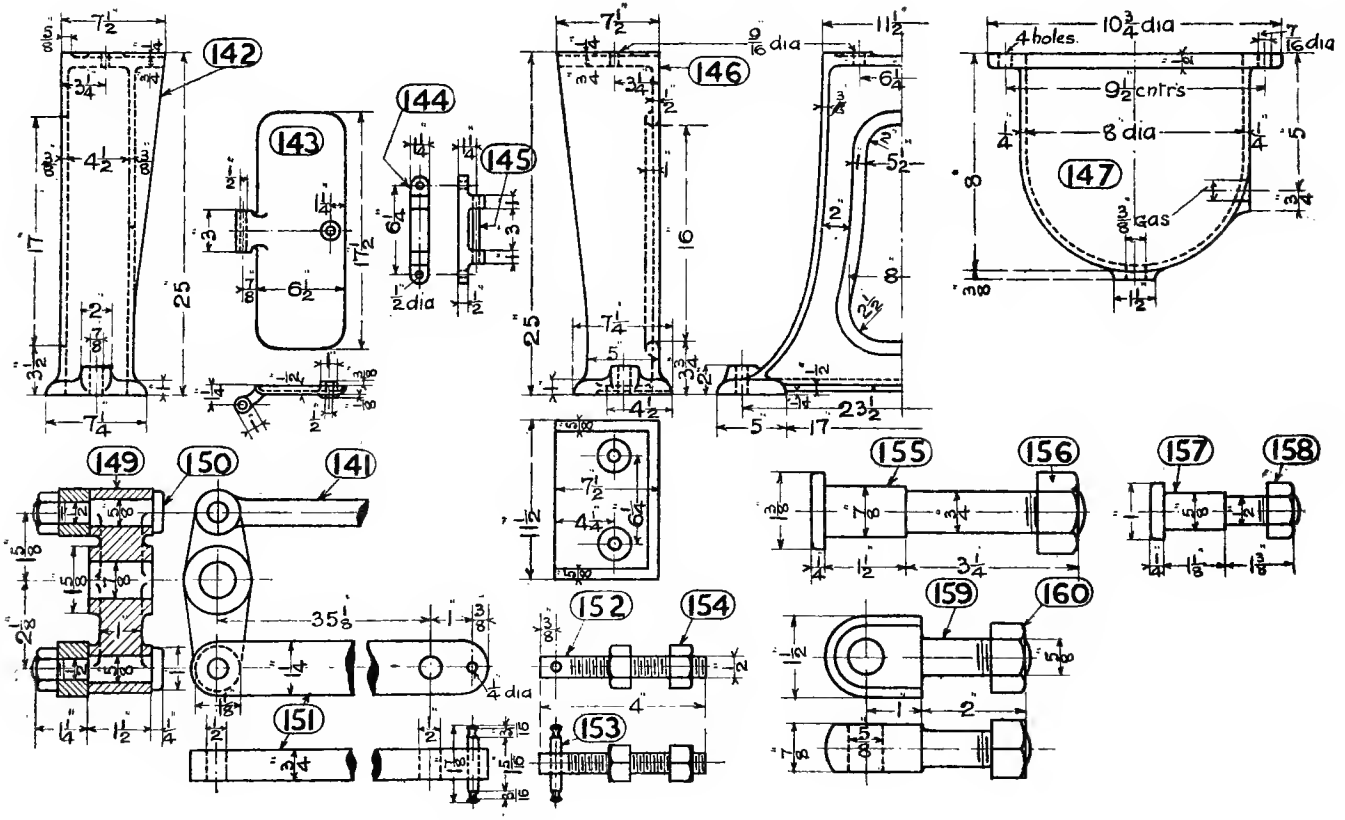
Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
116	Driving Shaft	Bright Drawn Steel	1	—
117	Pinion (spiral teeth, ½″ pitch)	Mild Steel	1	16 teeth
118	Key for Pinion	Key Steel	1	$\frac{5}{16}$″ × ¼″ × 1½″
119	Pinion and Shaft (6s D.P.)	Mild Steel	1	14 teeth
120	Gear Wheel (spiral teeth, ½″ pitch)	Cast Iron	1	1866 48 teeth
121	Key for Gear Wheel	Key Steel	1	$\frac{5}{16}$″ × ¼″ × 1⅛″
122	Sleeve for Cone Pulley	Cast Iron	1	1867
123	Hex. Hd. Set Bolts	Mild Steel	4	½″ × 1½″
124	Stauffer Lubricators	Brass	2	¼″ gas
125	Cone Pulley	Cast Iron	1	1868
126	,, ,, Driving Plate	,,	1	1869
127	Key for Cone Pulley (with ¼″ dia. peg)	Key Steel	1	$\frac{5}{16}$″ × ¼″ × 1¼″
128	Hex. Hd. Set Bolts	Mild Steel	2	½″ × 1½″
129	Fork for actuating Sleeve on Turning Head	Cast Iron	1	1870
130	Plates for Fork	Mild Steel	2	—
131	Fulcrum Pin for Fork	Mild Steel	1	—
132	Hex. Nuts for Fulcrum Pin for Fork	,,	2	⅝″
133	Washers for Fulcrum Pin for Fork (⅛″ thick)	,,	2	⅝″ hole 1¾″ dia.
134	Keys for Fulcrum Pin	,,	2	⅛″ × ⅛″ × 1¼″ with ¼″ dia. peg.
135	Lever for Fork	Cast Iron	1	1871
136	Key for Lever	Key Steel	1	¼″ × ¼″ × 2″
137	Knock-off Bracket for Saddle	Malleable Cast Iron	1	1872
138	Hex. Hd. Set Bolts for Knock-off Bracket for Saddle	Mild Steel	2	½″ × 1¼″
139	Stop Dog	Malleable Cast Iron	1	1873
140	Sq. Hd. Set Screw	Mild Steel	1	⅛″ × ¾″
141	Knock-off Rod	,,	1	—
141A	Taper Pin for Fork	,,	1	$\frac{5}{16}$″ × 2½″

Details of the Driving Gear, etc., for the Pipe-screwing Machine are shown on this plate.

Example 147.—Make separate detail working drawings of each of the following items: **122, 125, 126, 129,** and **131.**

Note.—In making the assembly drawing of the saddle, as per the instructions on page 197, the knock-off bracket (item **137**) is to be shown fixed in position on the base plate strip (item **20**), see Plates Nos. 81 and 82.

PLATE No. 87


142
143
144
145
146
147
149
150
141
151
152
153
154
155
156
157
158
159
160
4 holes.
9½ cntrs
8 dia
gas
4 dia

STANDS AND OIL TANK, ETC., FOR PIPE-SCREWING MACHINE

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
142	Left-hand Stand	Cast Iron	1	1874
143	Door for Left-hand Stand	,,	1	1875
144	Hinge Bracket	,,	1	1876
145	,, Pin	Mild Steel	1	$\frac{1}{2}'' \times 5''$
146	Right-hand Stand	Cast Iron	1	1877
147	Oil Tank	,,	1	1878
148	Hex. Head Set Bolts	Mild Steel	4	$\frac{3}{8}'' \times 1''$
149	Fulcrum Bracket	Cast Iron	1	1879
150	Pin Bolts for Fulcrum Bracket	Mild Steel	2	—
151	Connecting Rod	,,	1	—
152	Tension Rod	,,	1	—
153	Spring Pins		2	—
154	Hex. Nuts for Items **150** and **152**	,,	4	$\frac{1}{2}''$

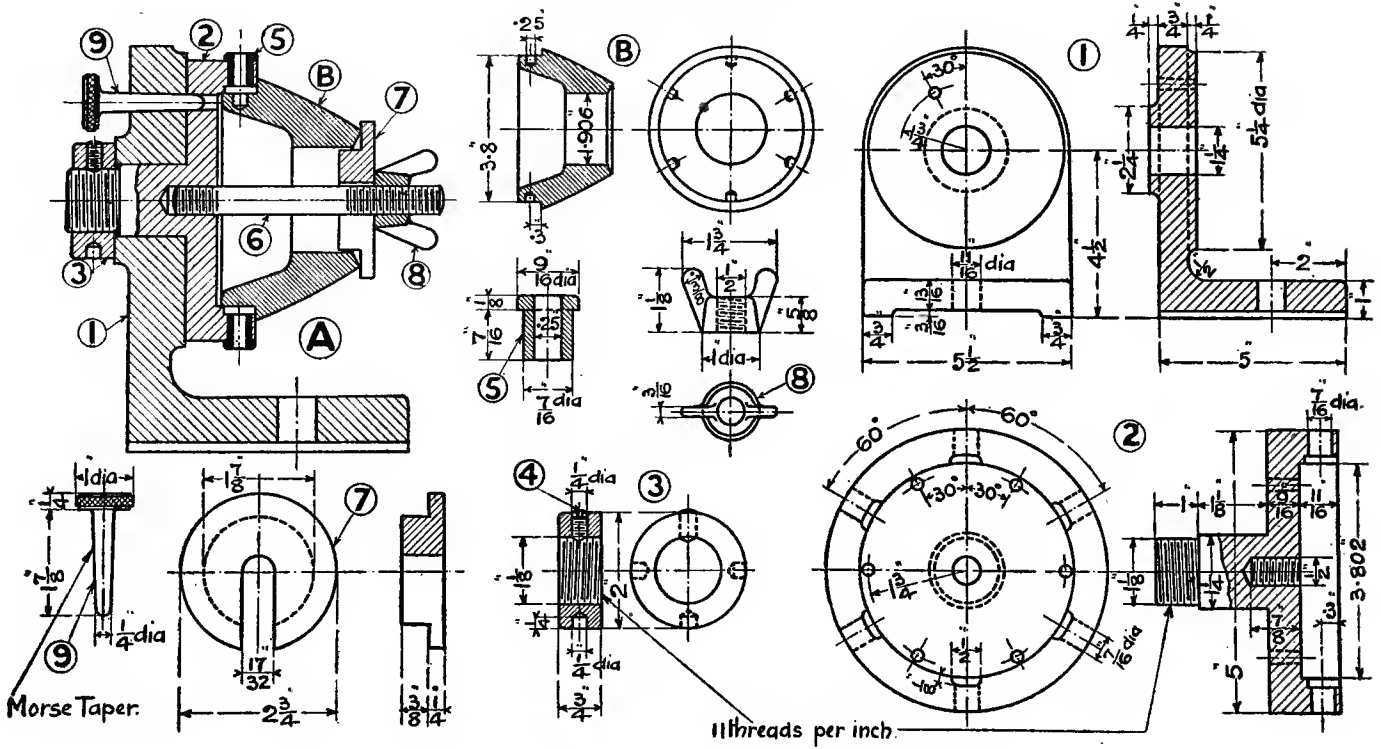
Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
155	Centre Bolt for Fulcrum Br'ket	Mild Steel	1	—
156	Hex. Nut for Centre Bolt for Fulcrum Bracket	,	1	$\frac{3}{4}''$
157	Pin Bolt for Connecting Rod	,,	1	—
158	Hex. Nut for Pin Bolt for Connecting Rod	,,	1	$\frac{1}{2}''$
159	Stanchion for Spring Rod	Malleable Cast Iron	1	1880
160	Hex. Nut for Stanchion for Spring Rod	Mild Steel	1	$\frac{5}{8}''$
161	Helical Springs for TensionRod	Spring Steel	2	—
162	Hex. Hd. Bolts and Nuts	Mild Steel	4	$\frac{5}{8}'' \times 2\frac{3}{4}''$
163	Washers for Hex. Hd. Bolts and Nuts	,,	4	$\frac{5}{8}''$

The illustration on the opposite page gives details of the Stands, Oil Tank, and Automatic Knock-off Arrangement, item **141** being the knock-off rod shown on the previous plate, No. 86.

The two pins (item **153**) are connected by light helical springs, which are not shown here, but are indicated in the general view of the machine shown on plate No. 78.

The left-hand stand is of box section, and is fitted with a hinged door providing a cabinet in which change wheels, spanners, etc., may be stored.

Example 148.—Make a drawing to a scale of $6'' = 1'$, showing two elevations and a plan of the left-hand stand (item **42**), with the door, etc., in position (items **143**, **144**, and **145**). Design a suitable handle and catch for the door.


A
B
1
2
3
4
5
6
7
8
9
Morse Taper.
11threads per inch.

DRILLING JIG FOR 6″ SHELL HEADS

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Angle Bracket	Cast Iron	1	171
2	Bush Ring	Mild Steel	1	—
3	,, ,, Nut	,,	1	—
4	Grub Screw	,,	1	¼″ × ½″
5	Bushes	Hardened Steel	6	—
6	Stud (screwed ⅜″ and 1¾″)	Mild Steel	1	½″ × 4¾″
7	Washer	Cast Iron	1	172
8	Wing Nut	Brass	1	173
9	Locating Peg	Mild Steel	1	—

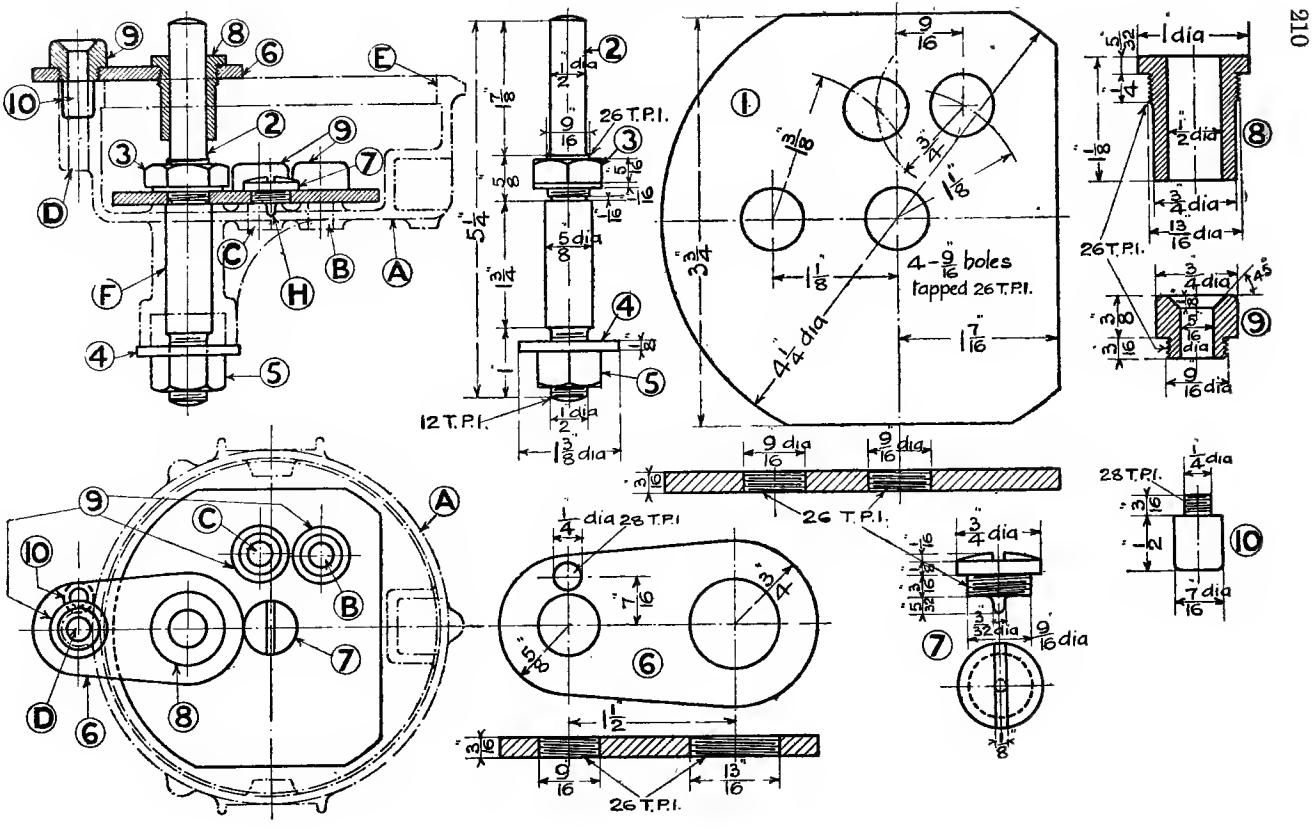
A simple Drilling Jig is illustrated on this plate. The jig shown is practically identical with one designed and used in the workshops at the Battersea Polytechnic when that department was engaged in the manufacture of munitions of war.

A general assembly of the jig with the shell head in position ready for drilling is shown at A. B is the shell head, and six holes require to be drilled, equally spaced round the periphery. The holes are clearly indicated in the two detail views of the head.

The jig consists of a cast-iron bracket (1) which is bolted to the drilling machine table. The bracket has a circular hole bored in its vertical flange into which is fitted the bush ring (2) which carries the six drilling bushes (5). This ring is secured to the bracket by the circular nut (3), so that, whilst there is no end play, the ring may be easily revolved by hand. The ring is fixed in the different positions required by means of the peg (9) which fits the tapered hole in the bracket and also the tapered holes in the ring. The shell head is held in position by means of the washer (4) and the wing nut (8). When the drilling operation is completed the wing nut is slacked back, the washer removed, and the shell head may be dismantled without the necessity of removing the wing nut from the stud, the washer being made with an open-ended slot to render this possible.

Example 149.—Make a full size drawing showing two elevations and a plan of the jig complete. One elevation to be as shown at A. Particulars of the shell head may be scaled from the illustration.

PLATE No. 89



DRILLING JIG FOR GEAR-BOX

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Base Plate	Steel	1	$3\frac{3}{4}'' \times 3\frac{9}{16}'' \times \frac{3}{16}''$
2	Spindle	Cast Steel	1	$\frac{5}{8}''$ dia. $5\frac{1}{4}''$ long
3	,, Nut (hex.), (tapped 26 threads per inch).	Mild Steel	1	$\frac{9}{16}''$
4	,, Washer	,,	1	$\frac{1}{8}''$ thick $1\frac{3}{8}''$ dia.
5	,, Nut (hex.)	,,	1	$\frac{1}{2}''$ standard
6	Swivel Arm	Steel	1	$2\frac{7}{8}'' \times 1\frac{1}{2}'' \times \frac{5}{16}''$
7	Locating Pin	Cast Steel	1	—
8	Swivel Bush	,,	1	—
9	Drilling Bushes	,,	3	—
10	Stop for Swivel Arm	,,	1	—

A Drilling Jig as used for the Gear-box of an Electric Drill is illustrated on the plate facing this page.

The gear-box itself is shown by chain dotted lines, and is marked A in the two assembly views; the holes for the drilling of which the jig is used being marked B, C, and D. Before the drilling is done the surface (E) of the gear-box is bored in the lathe, and at the same time the small pilot hole (H) is bored in the centre of the box. The casting is then mounted in a special bracket, and the hole (F) bored eccentric with the pilot hole. The drilling jig is then located by the spindle (2), which fits the hole (F), and the pin (7), the end of which fits into the pilot hole.

The position of hole D is located by the swivel arm (6). This arm is fitted with a stop (10) which is screwed into the $\frac{1}{4}''$ tapped hole. The stop butts against the lug on the gear-box, the arm being held in position whilst the hole is drilled.

Example 150.—Make a full size drawing showing two elevations and a plan of the jig complete. The gear-box itself need not be shown.

SECTION IX

1 CWT. STEAM HAMMER

1 CWT. STEAM HAMMER

COMPLETE details of a 1 Cwt. Steam Hammer are given on plates numbered 90 to 96, as follows:—

Plate No. 90.	Base plate, anvil block, piston, etc.
Plate No. 91.	Standards, etc.
Plate No. 92.	Cylinder and valves.
Plate No. 93.	Actuating gear details.
Plate No. 94.	Part arrangement of actuating gear.
Plate No. 95.	Foot gear details.
Plate No. 96.	Foundation plan.

Plate No. 94 also gives an "outside view" **elevation,** showing the general arrangement of the complete hammer. This elevation, and the descriptive text accompanying it, should be carefully considered before any of the work on the steam hammer is proceeded with.

The student will then be able to carry out the work in a more intelligent manner, thereby accentuating the interest and pleasure obtainable.

It may at once be stated that the term "1 cwt.," used in describing this hammer, indicates approximately the weight of the falling mass which strikes the blow, i.e. the tup, the tup pallett, the piston rod, and the piston. The force of the blow struck depends not only on the weight of this mass, but also on the pressure of the steam above the piston accelerating the fall of the mass. The energy of the blow, after full piston stroke, and just before striking, may be calculated as follows: E = energy. A = area of piston in square inches. P = average steam pressure on piston during downward stroke in lbs. per square inch. S = stroke of piston in feet. W = falling weight in lbs. $E = (AP + W)S$ foot-lbs.

The hammer may be worked either "self-acting," or each blow may be hand-controlled. Both methods of working are clearly indicated in the text accompanying Plate No. 95.

A lubricator, fitted with a hand pump (not shown on the illustrations), is affixed to one of the standards, and oil is pumped from this through a copper pipe to the stop valve chest, whence it is carried by the steam to the distributing valve and the cylinder.

The student is required to make various detail working drawings, particulars of which are given in the text accompanying the various plates.

EXAMPLE 151.—Make a general arrangement drawing of the hammer, complete, to the following particulars:—

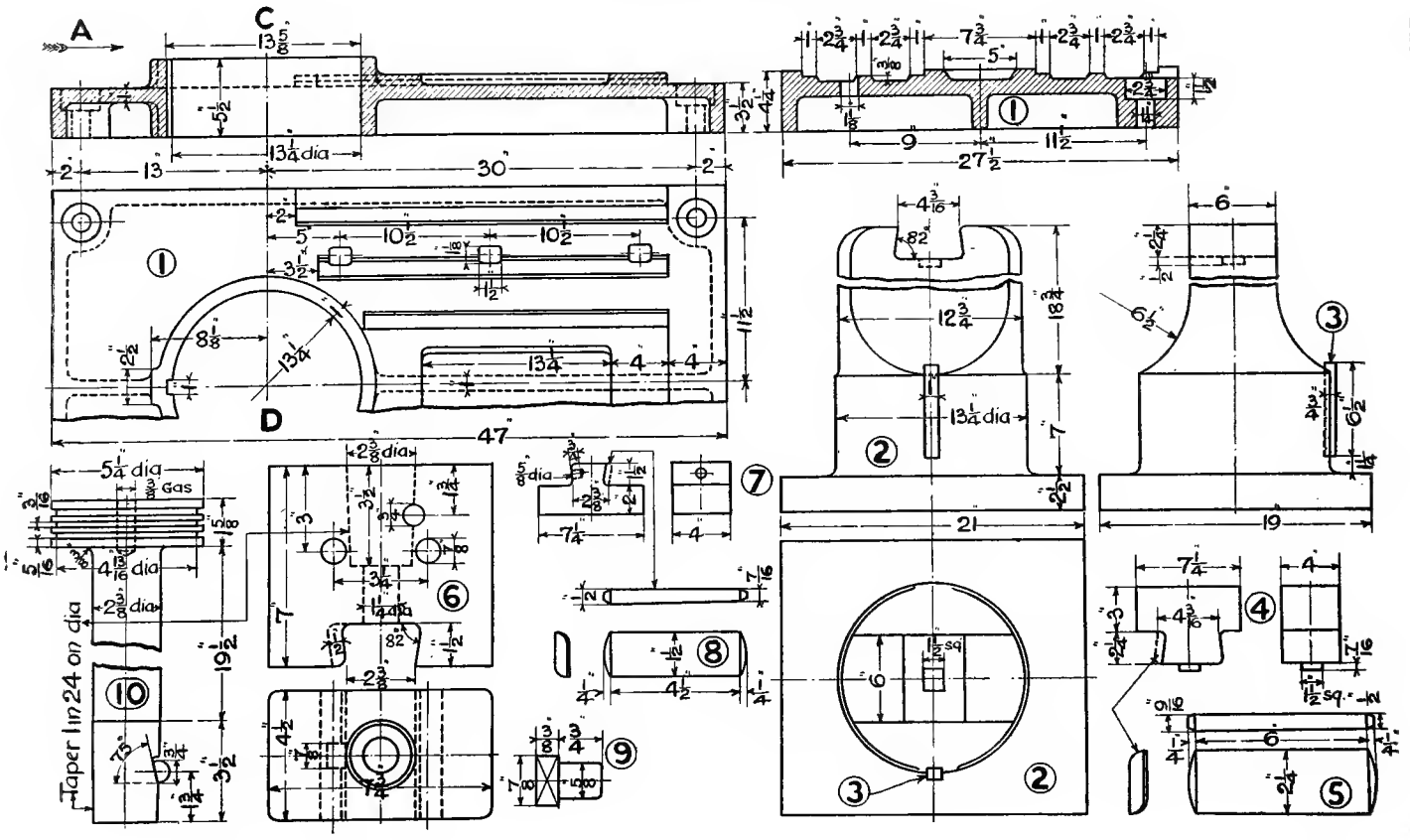
(*a*) An elevation corresponding to the elevation shown on Plate No. 94, but to be a sectional elevation, the section being taken on the centre line of the cylinder.

(*b*) An "end elevation," as seen when looking at the front of the hammer.

(*c*) An outside view plan.

(*d*) (If space permits.) An "end elevation," as seen when looking at the back of the hammer.

PLATE No. 90


A
C
D
13 dia
13¼ dia
30
47
2
13
5½
3½
11½
10½
8⅞
2½
5¼ dia
Gas
4 dia
2 dia
19½
Taper 1 in 24 on dia
2⅜ dia
7
6
82°
4½
9
11½
27½
5
7¼
4¾ dia
12¾
18¾
21
19
6
4
3
2
1
10
9
8
7

BASE PLATE, ETC., FOR 1 CWT. STEAM HAMMER

Reference Number.	Description.	Material.	Number Required.	Pattern No. or Size.
1	Base Plate	Cast Iron	1	975
2	Anvil Block . . .	,,	1	976
3	Key for Anvil Block .	Key Steel	1	1″ × $\frac{3}{4}$″ × 6$\frac{1}{2}$″
4	Anvil Pallett . .	Cast Steel	1	977
5	Key for Anvil Pallett . . .	Key Steel	1	2$\frac{1}{4}$″ × 1$\frac{3}{8}$″ × 6$\frac{1}{2}$″
6	Tup . . .	Mild Steel	1	7$\frac{3}{4}$″ × 7″ × 4$\frac{1}{2}$″
7	,, Pallett	Cast Steel	1	978
8	Key for Tup Pallett .	Key Steel	1	1$\frac{1}{2}$″ × $\frac{1}{2}$″ × 5″
9	Peg ,, ,, ,, . .	Mild Steel	1	$\frac{5}{8}$″ square 1$\frac{1}{2}$″ long
10	Piston and Rod . .	,,	1	—
11	Piston Rings .	Cast Iron	3	1$\frac{3}{4}$″ square section

Details of the Base Plate, Anvil, etc., for a 1 Cwt. Steam Hammer are given on this plate. The anvil block is made separately from the base plate, and is fixed to a more or less independent foundation. This is to save the framing of the hammer from the jarring effects produced by the blows on the anvil.

The anvil (2) fits the hole in the bed-plate (1), and is prevented from turning in it by means of the key (3). The upper part of the tup (6) is bored taper to receive the end of the piston rod, and is fixed thereto by a special key (item 95 plate 93). The lower part of the tup is slotted to receive the tup pallett (7), which is fixed to the tup by means of the key (8).

The peg (9) is driven tightly into the hole in the pallett, the head of the peg fitting in the small slot in the tup preventing the pallett from moving when the key (8) is driven home.

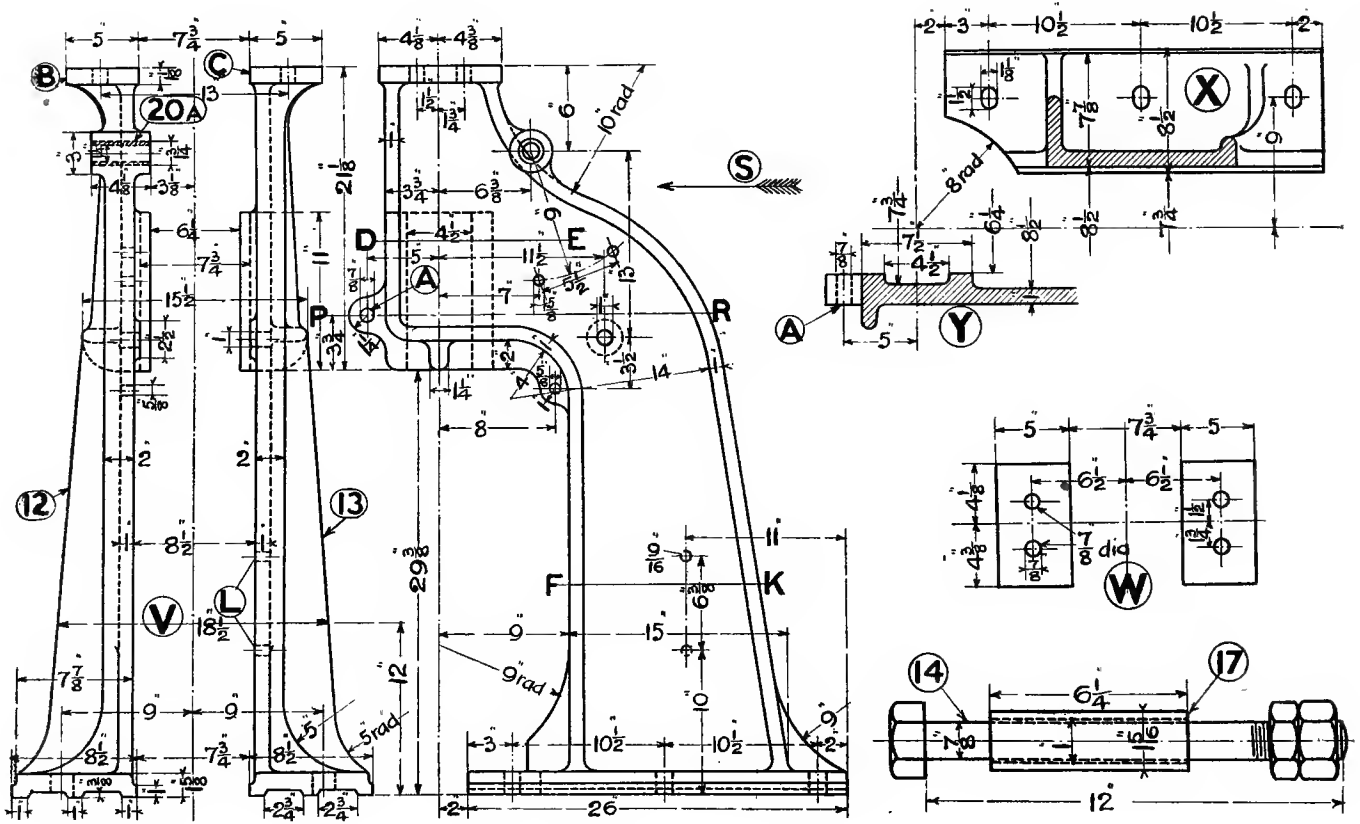
The anvil pallett (4) is fixed to the anvil by the key (5), and is prevented from moving by the square projection on the underside of the pallett which fits in a corresponding recess in the anvil block.

Example 152.—Make a complete working drawing of the base plate, showing the two elevations given on plate, and a **complete** plan.

To the right of the plan, and projected from it, make a sectional view, taking the section on line CD, looking in direction of arrow A.

Note.—The sectional end view given in the illustration is a conventional view, and includes a section through one of the holes for the foundation bolts.

PLATE No. 91



STANDARDS, ETC., FOR 1 CWT. STEAM HAMMER

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
12	Right-hand Standard . .	Cast Iron	1	979
13	Left-hand ,,	,,	1	980
14	Hex. Hd. Stay-bolt .	Mild Steel	1	$\frac{7}{8}$″ × 12″
15	,, Nut for Hex. Hd. Stay-bolt	,,	1	$\frac{7}{8}$″
16	Hex. Lock Nut for Hex. Nut	,,	1	$\frac{7}{8}$″
17	Distance Ferrule for Stay-bolt	Wro't Iron	1	1″ pipe 6¼″ long

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
18	Sq'h'd, Sq'n'k Bolts (standards to base plate)	Wro't Iron	6	1″ × 4½″ (black)
19	Hex. Nuts for Sq'h'd, Sq'n'k Bolts	,,	6	1″
20	Washer for Hex. Nuts . .	,,	6	1″
20A	Bush for Crank (4⅛″ long)	Gun Metal	1	1¾″ outs. dia. 1¼″ ins. dia.

The illustration shows various views of the Standards or Side Frames of a 1 Cwt. Steam Hammer.

View V is an end elevation looking on the back of the hammer (direction indicated by arrow S).

View W is a plan of the flanges B and C.

View X is a sectional half plan, the section being taken on line FK.

View Y is a sectional part plan, the section being taken on line DE.

The standards (**12** and **13**) are bolted to the base plate (item **1** on plate 90) by means of the six bolts and nuts (**18** and **19**).

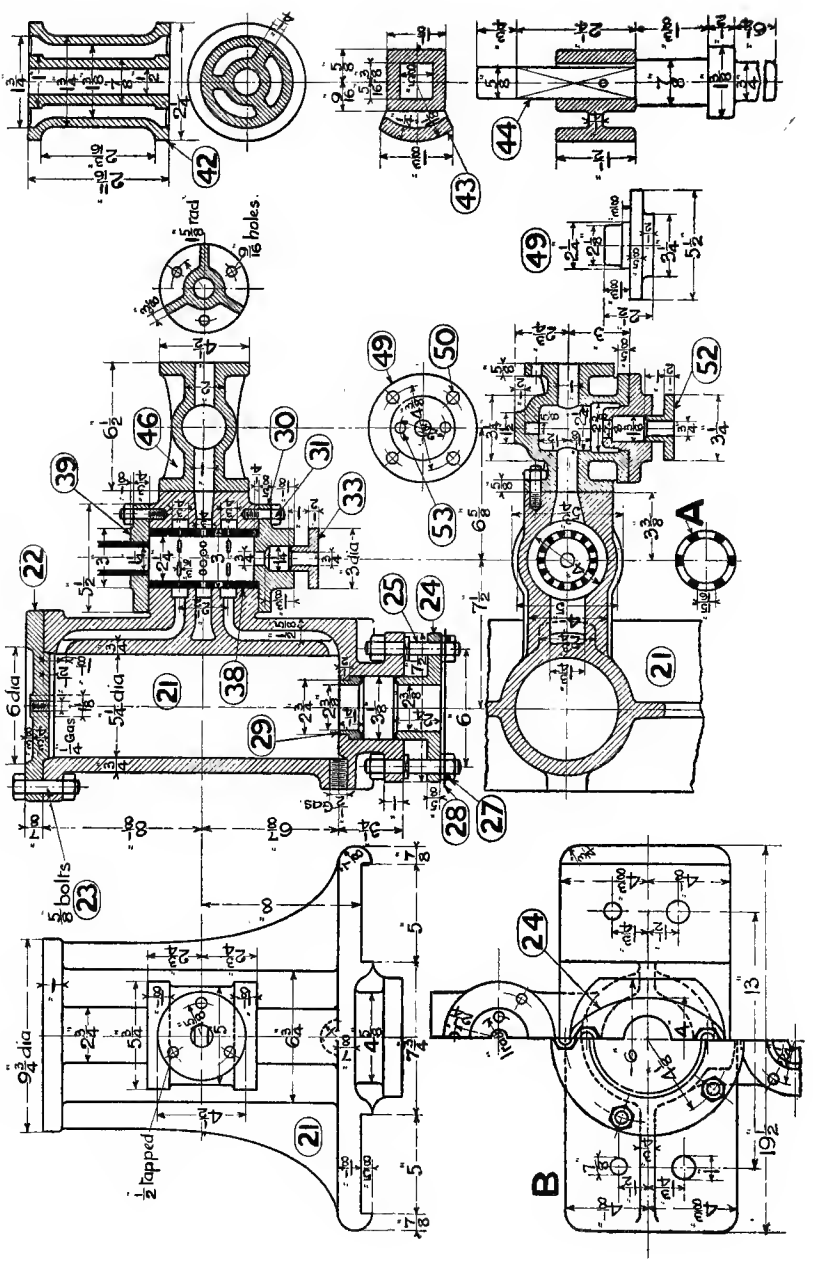
They are held rigidly together at the top by reason of the cylinder (item **21**, plate 92), being bolted to the upper flanges B and C. The standards are further stayed by means of the bolt and ferrule (items **14** to **17**), the bolt shank passing through the eyes marked A, the ferrule acting as a distance piece between the standards.

Example 153.—Make a working drawing of the standards, showing the elevations indicated, but having the stay-bolt and ferrule in their working positions. Also show sufficient of the base plate (item 1, plate 90) to show how the standards are fixed thereto by means of the bolts, nuts, and washers (items **18** to **20**).

Under these elevations and in projection with them show two plans. The plan under the end elevation to be an outside view plan. The plan under the side elevation to be a sectional view, the section being taken on line PR.

Example 154.—Trace the drawing made to Example 153.

PLATE No. 92



CYLINDER AND VALVES FOR 1 CWT. STEAM HAMMER

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
21	Cylinder	Cast Iron	1	981
22	,, Cover	,,	1	982
23	Hex. Hd. Bolts with Hex. Nuts	Mild Steel	5	$\frac{5}{8}$″ × 2$\frac{3}{4}$″
24	Gland	Gun Metal	1	983
25	Special Bolts for Gland	Mild Steel	2	$\frac{5}{8}$″ × 4$\frac{5}{8}$″
26	Hex. Nuts for Special Bolts for Gland	,,	4	$\frac{5}{8}$″
27	Split Pins for Nuts	,,	2	$\frac{1}{8}$″ × 2″
28	Locking Plate for Nuts	Wro't Iron	1	8$\frac{1}{8}$″ × 4$\frac{1}{4}$″ × 15s S.W.G.
29	Neck Bush	Gun Metal	1	984
30	Steam Chest Cover	Cast Iron	1	985
31	Studs for Steam Chest Cover (screwed $\frac{3}{4}$″ each end)	Mild Steel	3	$\frac{1}{2}$″ × 2″
32	Hex. Nuts for Studs	,,	3	$\frac{1}{2}$″
33	Gland for Steam Chest Cover	Gun Metal	1	986
34	Studs for Gland for St. Chest Cover (screwed 1$\frac{1}{2}$″ and $\frac{3}{4}$″)	Mild Steel	2	$\frac{1}{2}$″ × 2$\frac{1}{2}$″
35	Hex. Nuts for Studs	,,	2	$\frac{1}{2}$″
36	Split Pins for Nuts	,,	2	$\frac{1}{8}$″ × 1$\frac{1}{2}$″
37	Locking Plate for Nuts	Wro't Iron	1	3$\frac{1}{2}$″ dia. 15s S.W.G.
38	Valve Tube	Gun Metal	1	987
39	Exhaust Pipe Flange	Cast Iron	1	988

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
40	Studs for Exhaust Pipe Flange (screwed $\frac{3}{4}$″ each end)	Mild Steel	3	$\frac{1}{2}$″ × 2″
41	Hex. Nuts for Studs	,,	3	$\frac{1}{2}$″
42	Piston Valve	Gun Metal	1	989
43	Stop ,,	,,	1	990
44	,, ,, Spindle	Mild Steel	1	—
45	Split Pin for Stop Valve Spindle	,,	1	$\frac{1}{8}$″ × 1$\frac{3}{4}$″
46	Stop Valve Casing	Cast Iron	1	991
47	Studs for Stop Valve Casing (screwed $\frac{3}{4}$″ each end)	Mild Steel	3	$\frac{1}{2}$″ × 2″
48	Hex. Nuts for Studs	,,	3	$\frac{1}{2}$″
49	Stop Valve Cover	Cast Iron	1	992
50	Studs for Stop Valve Cover (screwed $\frac{3}{4}$″ each end)	Mild Steel	4	$\frac{1}{2}$″ × 2″
51	Hex. Nuts for Studs	,,	4	$\frac{1}{2}$″
52	Gland for Stop Valve Cover	Gun Metal	1	993
53	Studs for Gland for Stop Valve Cover (screwed 1$\frac{1}{2}$″ and $\frac{3}{4}$″)	Mild Steel	2	$\frac{1}{2}$″ × 2$\frac{1}{2}$″
54	Hex. Nuts for Studs	,,	2	$\frac{1}{2}$″
55	Split Pins for Nuts	,,	2	$\frac{1}{8}$″ × 1$\frac{1}{2}$″
56	Locking Plate for Nuts	Wro't Iron	1	3$\frac{3}{4}$″ dia. × 15s S.W.G.
56A	Cheese Hd. Bolts with Hex. Nuts and Lock Nuts	Mild Steel	4	2 bright, 2 black $\frac{5}{8}$″ × 4″
56B	Drain Cock	Brass	1	Screwed $\frac{1}{2}$″ gas

Details of the Cylinder and Valves for a 1 Cwt. Steam Hammer are given on this plate. The left-hand half of the plan marked B shows the ordinary top view plan with the cylinder cover removed. The right-hand half is an inverted plan.

View A is a section through the valve tube, the section being taken through either the top or bottom ports.

These ports are twelve in number (six in each row) and are $\frac{15}{16}'' \times \frac{3}{16}''$. There are fourteen ports in the middle row, each $\frac{3}{8}''$ diameter.

Special precautions are taken for locking the nuts of the gland studs. In the case of gland (**24**) a plate (**28**) similar in shape to the gland flange has a central hole $2\frac{1}{8}''$ diameter and two hexagonal holes to fit the nuts on the studs. This plate is supported by the split pins (**27**) which pass through the nuts but not through the studs.

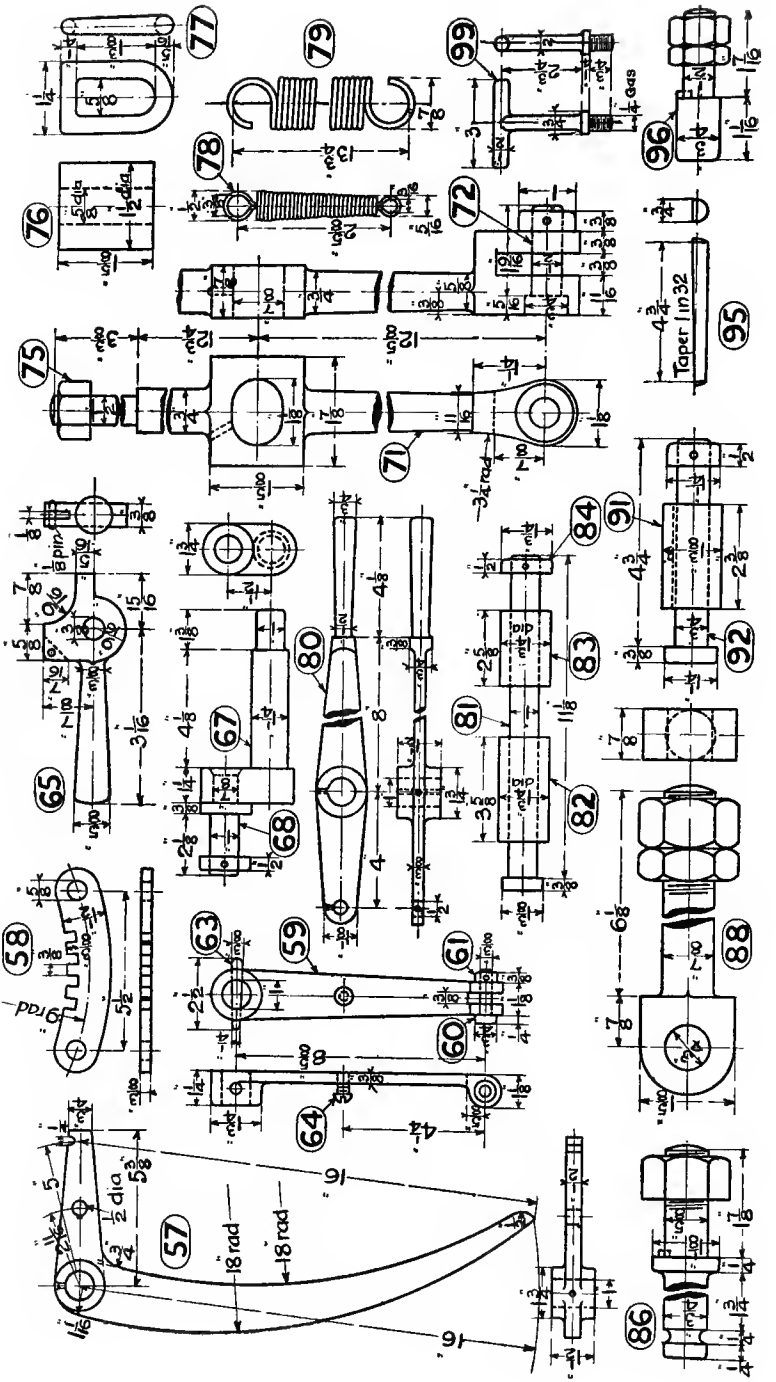
A similar provision is made for the other glands, the locking plates in both the remaining cases being circular in shape.

EXAMPLE 155.—Make a separate detail working drawing of item **21**.

EXAMPLE 156.—Make a full size drawing of the stop valve and casing complete, showing items **43** to **56** in their working positions, and give a full detail of item **56**.

EXAMPLE 157.—Trace the drawing made in Example 155.

PLATE No. 93



ACTUATING GEAR DETAILS FOR 1 CWT. STEAM HAMMER

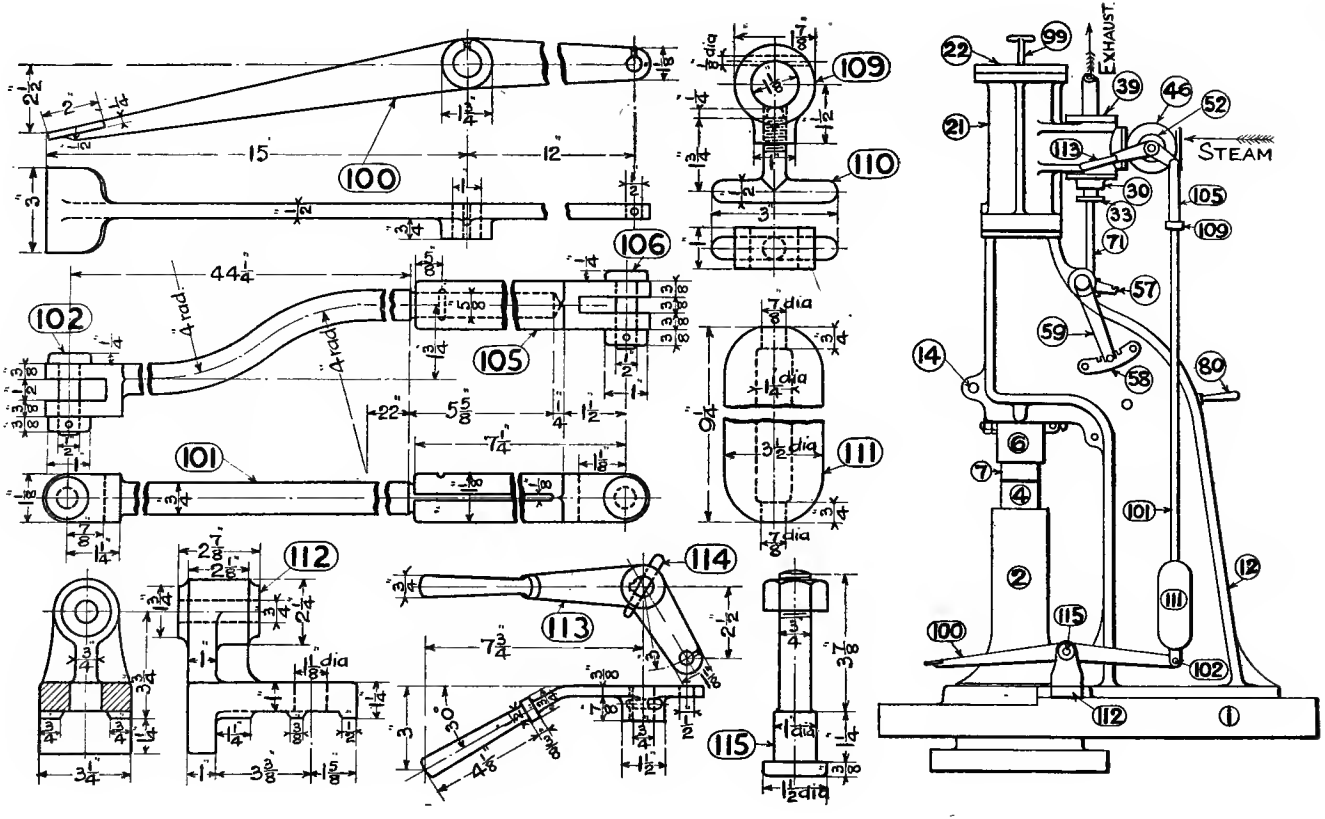
Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
57	Radius Lever	Wro't Iron	1	—
58	Quadrant	,,	1	—
59	,, Lever	,,	1	—
60	Pin for Quadrant Lever	Mild Steel	1	$\frac{3}{8}$″ × 1$\frac{1}{2}$″
61	Collar for Pin	,,	1	$\frac{3}{4}$″ dia. $\frac{3}{8}$″ thick
62	Split Pin	,,	1	$\frac{5}{32}$″ dia. 1$\frac{1}{2}$″ long
63	Taper ,, (tapered $\frac{3}{8}$″ to $\frac{1}{4}$″ dia.)	,,	1	2$\frac{1}{2}$″ long
64	Cup Head Set Screw	,,	1	$\frac{3}{8}$″ × $\frac{3}{4}$″
65	Quadrant Handle	Wro't Iron	1	—
66	Pin for Quadrant Handle	Mild Steel	1	$\frac{1}{8}$″ × $\frac{1}{2}$″
67	Crank	,,	1	—
68	,, Pin	,,	—	—
69	,, ,, Collar	,,	1	1$\frac{3}{4}$″ dia. $\frac{1}{2}$″ thick
70	Split ,,	,,	1	$\frac{1}{8}$″ × 2$\frac{1}{2}$″
71	Spindle for Piston Valve	Wro't Iron	1	—
72	Pin for Spindle for Piston Valve	Mild Steel	1	$\frac{1}{2}$″ × 1$\frac{9}{16}$″
73	Collar for Pin	,,	1	1″ dia. $\frac{3}{8}$″ thick
74	Split Pin	,,	1	$\frac{1}{8}$″ × 1$\frac{3}{4}$″
75	Hex. Nut for Spindle	,,	1	$\frac{1}{2}$″
76	Ferrules for Quadrant	Cast Iron	2	994
77	Spring Link	Wro't Iron	1	—
78	,, for Quadrant Lever	Spring Steel	1	No. 14s B.W.G.
79	,, ,, Radius Lever	,,	1	No. 8s B.W.G.

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
80	Hand Lever	Wro't Iron	1	—
81	Fulcrum Pin for Hand Lever	Mild Steel	1	1″ dia. 11$\frac{1}{2}$″ long
82	Long Ferrule for Fulcrum Pin	Cast Iron	1	995
83	Short ,, ,, ,, ,,	,,	1	996
84	Collar for Fulcrum Pin	Mild Steel	1	1$\frac{3}{4}$″ dia. $\frac{1}{2}$″ thick
85	Split Pin for Collar	,,	1	$\frac{5}{16}$″ × 2$\frac{1}{2}$″
86	Spring Stud for Radius Lever	,,	1	—
87	Hex. Nut for Spring Stud for Radius Lever	,,	1	$\frac{5}{8}$″
88	Eye-bolts for Tup Roller Pin	Wro't Iron	2	$\frac{7}{8}$″ × 6$\frac{1}{8}$″
89	Hex. Nuts for Eye-bolts	Mild Steel	2	$\frac{7}{8}$″
90	,, Lock Nuts for Eye-bolts	,,	2	$\frac{7}{8}$″
91	Tup Roller	,,	1	1$\frac{3}{8}$″ dia. 2$\frac{3}{8}$″ long
92	,, ,, Pin	,,	1	$\frac{3}{4}$″ × 4$\frac{3}{4}$″
93	Collar	,,	1	1$\frac{1}{4}$″ dia. $\frac{1}{2}$″ thick
94	Split Pin	,,	1	$\frac{5}{16}$″ × 2$\frac{1}{2}$″
95	Key for Piston Rod to Tup	Key Steel	1	$\frac{3}{4}$″ dia. 5″ long
96	Lifting Stud	Mild Steel	1	$\frac{5}{8}$″ dia. 2$\frac{1}{2}$″ long
97	Hex. Nut for Stud	,,	1	$\frac{1}{2}$″
98	,, Lock Nut for Stud	,,	1	$\frac{1}{2}$″
99	Grease Plug for Cylinder Cover	Wro't Iron	1	—
99A	Hex. Hd. Bolts, with Hex. Nuts for Quadrant	Mild Steel	2	$\frac{5}{8}$″ × 3$\frac{3}{4}$″

Most of the details indicated here are shown in their **working** positions on Plates Nos. 94 and 95.

Note.—The oil holes in items **57**, **71**, **80**, and **91** are $\frac{1}{8}$″ diameter, and the oil groove in item **91** is $\frac{1}{8}$″ wide × $\frac{1}{16}$″ deep.

PLATE No. 94


100
101
102
105
106
109
110
111
112
113
114
115
15"
12"
44¼"
4" rad
4" rad
22"
5⅝"
7¼"
7" dia
3½" dia
1" dia
1½" dia
30°
EXHAUST
STEAM
22
99
39
46
52
21
113
30
105
33
109
71
57
59
58
80
14
6
7
4
2
101
12
111
115
100
102
112
1

FOOT LEVER DETAILS FOR 1 CWT. STEAM HAMMER

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
100	Foot Lever	Wro't Iron	1	—
101	Connecting Rod	,,	1	—
102	,, ,, Pin	Mild Steel	1	$\frac{1}{2}$" × $1\frac{1}{4}$"
103	,, ,, ,, Collar	,,	1	1" dia. $\frac{3}{8}$" thick
104	Split Pin for Collar	,,	1	$\frac{1}{8}$" × $1\frac{3}{4}$"
105	Connecting Rod Socket	Wro't Iron	1	—
106	Pin for Connecting Rod Socket	Mild Steel	1	$\frac{1}{2}$" × $1\frac{5}{8}$"
107	Collar for Pin	,,	1	1" dia. $\frac{3}{8}$" thick
108	Split Pin for Collar	,,	1	$\frac{1}{4}$" × $1\frac{3}{4}$"
109	Binding Collar	Cast Iron	1	997
109A	Pin for Binding Collar	Mild Steel	1	$\frac{1}{8}$" × $1\frac{5}{8}$"
110	Screw for Binding Collar	Wro't Iron	1	—

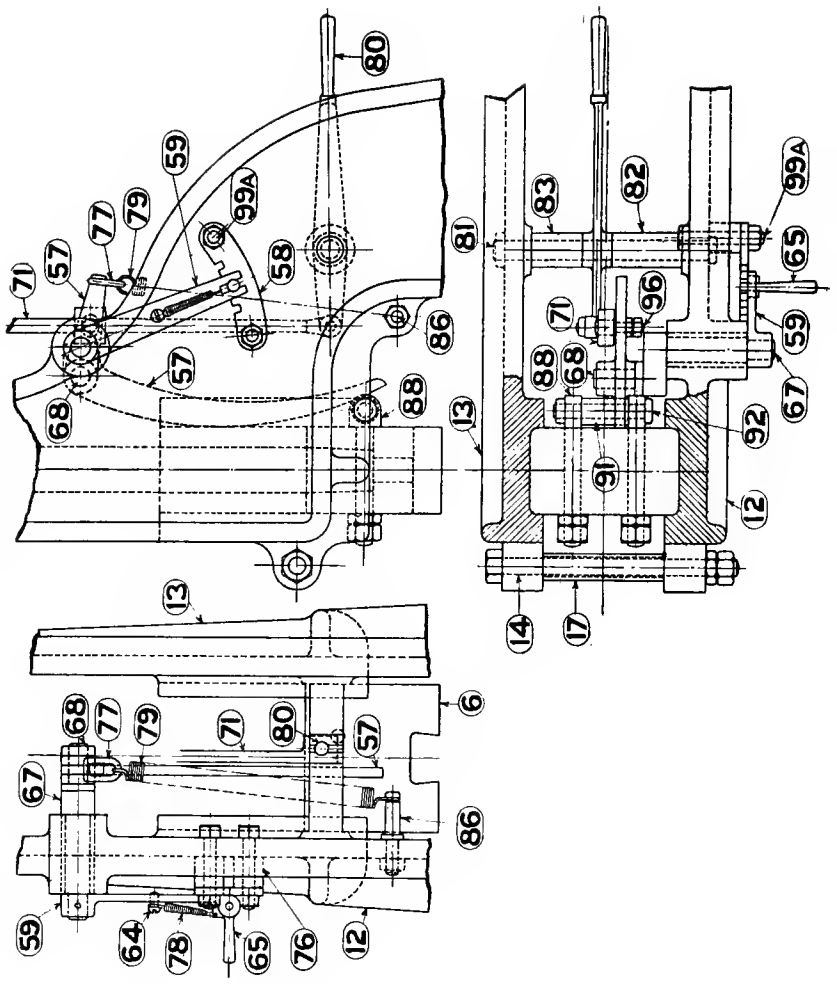
Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
111	Balance Weight	Cast Iron	1	998
112	Foot Lever Fulcrum Bracket	,,	1	999
113	Stop Valve Lever	Wro't Iron	1	—
114	Taper Pin for Stop Valve Lever (tapered $\frac{3}{8}$" to $\frac{1}{4}$" dia.)	Mild Steel	1	$2\frac{1}{2}$" long
115	Fulcrum Pin for Foot Lever	,,	1	—
116	Hex. Nut for Fulcrum Pin for Foot Lever	,,	1	$\frac{3}{4}$"
117	Sq'h'd, Sq'n'k Bolt for Fulcrum Bracket	Wro't Iron	1	1" × 6"
118	Hex. Nut for item 117	Mild Steel	1	1"
119	Washer for Hex. Nut	,,	1	1"

All the details shown on this plate require to be embodied in the general arrangement drawing called for on page 215.

The elevation of the complete hammer shown on the right-hand of the illustration indicates the working positions of the various details of the foot gear. From this it can be seen that, with the actuating gear in the "self-acting" position, the hammer may be worked single handed by the smith himself, since he can control the stop valve by means of the foot gear.

The general assembly of all the main parts of the hammer being also shown here, this elevation, together with the illustration on Plate No. 95, will materially assist the student in making the general arrangement drawing referred to above.

PLATE No. 95


80
59
99A
79
77
57
71
58
86
57
68
88
13
81
83
82
99A
65
59
67
71
96
88
68
92
91
12
14
17
13
6
68
77
79
71
80
57
67
86
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64
78
65
76
12

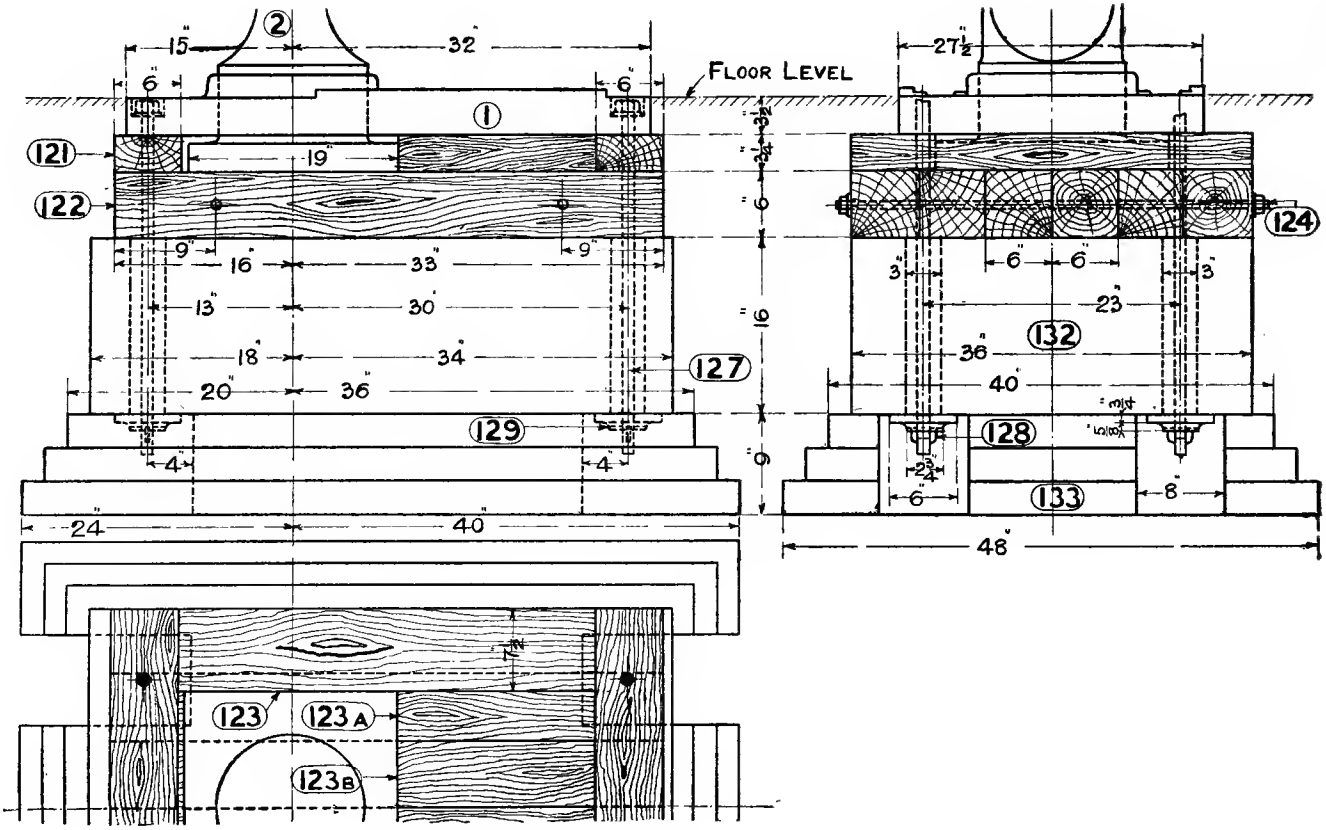
PART ARRANGEMENT OF ACTUATING GEAR FOR 1 CWT. STEAM HAMMER

The working positions of the Actuating Gear Details are indicated in the illustration facing this page. As previously stated, the hammer is either worked by hand control or is self-acting. In the former case every blow is regulated and controlled through the medium of the lever (**80**). This lever is attached by a pin-joint to the valve rod (**71**), which, in turn, is attached to the distributing valve in the cylinder. A downward movement of the lever handle causes an upward movement of the valve. This frees the exhaust from below the piston, and admits steam above it, which causes the downward movement of the piston and tup.

When the gear is "self-acting" the valve rod (**71**) gets its upward motion through the action of the lever (**57**). The lower end of this lever rests against the roller (**91**) carried by the eye-bolts (**88**) which are attached to the tup (**6**). As the tup makes its upward stroke the lever (**57**), pivoted on the crank pin (**68**), is forced over to the right. A lifting pin (**96**) fixed in the upper arm of lever (**57**) and projecting into the elongated hole in the valve spindle (**71**) forces the spindle, and with it the valve, upwards, ready for the downward stroke. As the downward stroke is made the lever (**57**) is brought back to position by the spring (**79**). The range of movement of the valve can be varied by altering the position of the lever (**59**), a quadrant (**58**) with notches being provided for this purpose. Various positions for the lever (**59**) giving different positions for the crank-pin (**68**) are provided. With the quadrant handle catch in the right-hand notch of the quadrant the self-acting gear and the piston valve are lowered, so that at the uppermost point of the valve travel, due to self-acting gear, steam is not admitted above the piston. The hammer can then only be worked by the hand lever (**80**). In either of the middle positions the self-acting gear is lifted into its working position, and provides a quick blow of short stroke.

When the left-hand notch is used full stroke of the piston is obtained, and this gives a slower but heavier blow.

PLATE No. 96


2
15"
32"
6"
6"
FLOOR LEVEL
1
121
19"
122
9"
16"
33"
9"
13"
30"
18"
34"
127
20"
36"
129
4"
4"
24"
40"
27½"
3½"
6"
124
3"
6"
6"
3"
23"
132
36"
40"
16"
9"
128
2¾"
2¾"
6"
133
8"
48"
123
123A
123B

FOUNDATION FOR 1 CWT. STEAM HAMMER

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
121	Joists	Pitch Pine	2	6″ × 3½′ × 36
122	,, ...	,,	6	6″ × 6″ × 49″
123	,, ...	,	2	7½″ × 3½″ × 37″
123A	,, ...	,,	2	4½″ × 3¼″ × 17½″
123B	,, ...	,,	2	6″ × 3¼″ × 17½″
124	Bracing Bolts . .	Wro't Iron	2	¾″ × 38″
125	Hex. Nuts for Bracing Bolts .	,,	4	¾″
126	Washers for Bracing Bolts	,,	4	¾″

Ref. Number.	Description.	Material.	Number Reqd.	Pattern No. or Size.
127	Foundation Bolts . . .	Wro't Iron	4	1″ × 32½″
128	Cotters for Foundation Bolts .	Mild Steel	4	2″ × 1¼″ × ¼″
129	Anchor Plates . . .	Cast Iron	4	1000
130	Hex. Nuts for Foundation Bolts	Wro't Iron	4	1″
131	Washers for Foundation Bolts	,,	4	1″
132	Stone Work .	—	—	52″ × 36″ × 16″
133	Brick Work	—	—	As per drg.

The Foundation for a Steam Hammer is so constructed as to provide a certain amount of spring so as to eliminate as much of the harshness of the hammer blows as possible.

This springiness being provided, not only is there less vibration caused to adjacent buildings, but the efficiency and life of the hammer are increased. A little increase in the cost of the foundation is, therefore, an actual economy.

The foundation indicated in the illustration is a suitable minimum in cases where the sub-foundation is good firm ground.

If it is necessary to still further minimise vibration, the depth of the stone work should be greater.

If the sub-foundation is solid rock, then the depth of the timber under the anvil block should be doubled. If concrete is used in preference to stone, the size of this part of the foundation should be slightly greater than shown on the drawing.

In making the foundation, the anvil block (2) is **raised** half an inch above its lowest safe working position to allow for any settling that may take place in the foundation. Such allowance has been made in the arrangement shown. This is a point of the utmost importance, as should the anvil block settle more than a certain amount, the piston will crash through the lower end of the cylinder.

Cottered foundation bolts are used, hand-holes being made in the brickwork to allow of the insertion of the cotters.

The anchor plates are square, and have a square projection on their lower faces. Slots, ⅜″ wide × ¼″ deep, into which the cotters fit, are cut through these projections.

BRITISH STANDARD

WHITWORTH SCREW THREADS AND HEXAGONAL NUTS AND BOLT HEADS

Diameter of Bolt in Inches.	No. of Threads per Inch.	Diameter at Bottom of Threads in Inches.	Sectional Area at Bottom of Threads in Sq. Inches.	Bright Hexagonal Nuts and Bolt Heads.		Thickness of Lock Nut (Max.) in Inches.
				Size Across Flats (Max.) in Inches.	Size Across Corners (Max.) in Inches.	
$\frac{1}{4}$	20	·186	·0272	·525	·61	·18
$\frac{5}{16}$	18	·2414	·0458	·600	·69	·22
$\frac{3}{8}$	16	·295	·0683	·710	·82	·26
$\frac{7}{16}$	14	·346	·094	·820	·95	·30
$\frac{1}{2}$	12	·3933	·1215	·920	1·06	·34
$\frac{9}{16}$	11	·5086	·2032	1·100	1·27	·43
$\frac{5}{8}$	10	·6219	·3038	1·300	1·5	·51
$\frac{7}{8}$	9	·7327	·4216	1·480	1·71	·59
1	8	·8399	·5540	1·670	1·93	·68
$1\frac{1}{8}$	7	·942	·6969	1·860	2·15	·77
$1\frac{1}{4}$	7	1·067	·8942	2·050	2·37	·85
$1\frac{3}{8}$	6	1·1616	1·0597	2·220	2·56	·94
$1\frac{1}{2}$	6	1·2866	1·3001	2·410	2·78	1·02
$1\frac{5}{8}$	5	1·3689	1·4718	2·580	2·98	1·10
$1\frac{3}{4}$	5	1·4939	1·7528	2·760	3·19	1·19
2	$4\frac{1}{2}$	1·7154	2·3111	3·150	3·64	1·35
$2\frac{1}{4}$	4	1·9298	2·9249	3·550	4·10	1·52
$2\frac{1}{2}$	4	2·1798	3·7318	3·890	4·49	1·69
$2\frac{3}{4}$	$3\frac{1}{2}$	2·3841	4·4641	4·180	4·83	1·85
3	$3\frac{1}{2}$	2·6341	5·4496	4·530	5·23	2·02
$3\frac{1}{4}$	$3\frac{1}{4}$	2·8560	6·4063	4·850	5·60	2·19
$3\frac{1}{2}$	$3\frac{1}{4}$	3·106	7·5769	5·180	5·98	2·35
$3\frac{3}{4}$	3	3·3231	8·6732	5·550	6·41	2·52
4	3	3·5731	10·0272	5·950	6·87	2·69
$4\frac{1}{2}$	$2\frac{7}{8}$	4·0546	12·9118	6·820	7·88	3·03
5	$2\frac{3}{4}$	4·5343	16·1477	7·800	9·01	3·36
$5\frac{1}{2}$	$2\frac{5}{8}$	5·0121	19·7301	8·850	10·22	3·7
6	$2\frac{1}{2}$	5·4877	23·6521	10·000	11·55	4·03

Standard square threads.—No. per inch = half the No. of Vee threads for same diameter.

Thickness of standard nut = diameter of bolt.

Thickness of standard bolt head = $\frac{7}{8}$ths of diameter of bolt.

NOTE.—The above table is reproduced by permission of the British Engineering Standards Association from their Reports, Nos. 34 and 28.

BRITISH STANDARD PIPE THREADS

Internal Dia. of Pipe in Inches.	External Dia. of Pipe in Inches.	No. of Threads Per Inch.	Length of Screwing in Inches.
$\frac{1}{8}$	$\frac{13}{32}$	28	$\frac{3}{8}$
$\frac{1}{4}$	$\frac{17}{32}$	19	$\frac{3}{8}$
$\frac{3}{8}$	$\frac{11}{16}$	19	$\frac{1}{2}$
$\frac{1}{2}$	$\frac{27}{32}$	14	$\frac{5}{8}$
$\frac{5}{8}$	$\frac{15}{16}$	14	$\frac{5}{8}$
$\frac{3}{4}$	$1\frac{1}{16}$	14	$\frac{3}{4}$
$\frac{7}{8}$	$1\frac{7}{32}$	14	$\frac{3}{4}$
1	$1\frac{11}{32}$	11	$\frac{7}{8}$
$1\frac{1}{4}$	$1\frac{15}{16}$	11	1
$1\frac{1}{2}$	$1\frac{23}{32}$	11	1
$1\frac{3}{4}$	$2\frac{3}{32}$	11	$1\frac{1}{8}$
2	$2\frac{3}{16}$	11	$1\frac{1}{8}$
$2\frac{1}{4}$	$2\frac{7}{16}$	11	$1\frac{1}{4}$
$2\frac{1}{2}$	3	11	$1\frac{1}{4}$
$2\frac{3}{4}$	$3\frac{1}{4}$	11	$1\frac{3}{8}$
3	$3\frac{1}{2}$	11	$1\frac{3}{8}$
$3\frac{1}{4}$	$3\frac{3}{4}$	11	$1\frac{1}{2}$
$3\frac{1}{2}$	4	11	$1\frac{1}{2}$
$3\frac{3}{4}$	$4\frac{1}{4}$	11	$1\frac{1}{2}$
4	$4\frac{1}{2}$	11	$1\frac{5}{8}$
$4\frac{1}{2}$	5	11	$1\frac{5}{8}$
5	$5\frac{1}{2}$	11	$1\frac{3}{4}$
$5\frac{1}{2}$	6	11	$1\frac{7}{8}$
6	$6\frac{1}{2}$	11	2

BRITISH STANDARD FINE THREADS

Dia. in Inches.	No. of Threads Per Inch.	Dia. at Bottom of Threads in Inches.	Sectional Area at Bottom of Threads in Sq. Inches.
$\frac{7}{32}$	28	·1731	·0235
$\frac{1}{4}$	26	·2007	·0316
$\frac{9}{32}$	26	·2320	·0423
$\frac{5}{16}$	22	·2543	·0508
$\frac{3}{8}$	20	·3110	·0760
$\frac{7}{16}$	18	·3664	·1054
$\frac{1}{2}$	16	·4200	·1385
$\frac{9}{16}$	16	·4825	·1828
$\frac{5}{8}$	14	·5335	·2235
$\frac{11}{16}$	14	·5960	·2790
$\frac{3}{4}$	12	·6433	·3250
$\frac{13}{16}$	12	·7058	·3913
$\frac{7}{8}$	11	·7586	·4520
1	10	·8719	·5971
$1\frac{1}{8}$	9	·9827	·7585
$1\frac{1}{4}$	9	1·1077	·9637
$1\frac{3}{8}$	8	1·2149	1·1592
$1\frac{1}{2}$	8	1·3399	1·4100
$1\frac{5}{8}$	8	1·4649	1·6854
$1\frac{3}{4}$	7	1·5670	1·9285
2	7	1·8170	2·5930
$2\frac{1}{4}$	6	2·0366	3·2577
$2\frac{1}{2}$	6	2·2866	4·1065
$2\frac{3}{4}$	6	2·5366	5·0535
3	5	2·7439	5·9133

NOTE.—These tables are reproduced by permission of the British Engineering Standards Association from their Reports, Nos. 34 and 84.

STANDARD THREADS

UNITED STATES ("Sellers")

Diameter in Inches.	No. of Threads per Inch.
$\frac{1}{4}$	20
$\frac{5}{16}$	18
$\frac{3}{8}$	16
$\frac{7}{16}$	14
$\frac{1}{2}$	13
$\frac{9}{16}$	11
$\frac{5}{8}$	10
$\frac{3}{4}$	9
$\frac{7}{8}$	8
1	7
$1\frac{1}{8}$	7
$1\frac{1}{4}$	6
$1\frac{3}{8}$	6
$1\frac{1}{2}$	$5\frac{1}{2}$
$1\frac{5}{8}$	5
$1\frac{3}{4}$	$4\frac{1}{2}$
2	$4\frac{1}{2}$
$2\frac{1}{4}$	4
$2\frac{1}{2}$	4
$2\frac{3}{4}$	$3\frac{1}{2}$
3	$3\frac{1}{2}$
$3\frac{1}{4}$	$3\frac{1}{4}$
$3\frac{1}{2}$	3
$3\frac{3}{4}$	3
4	$2\frac{3}{4}$
$4\frac{1}{2}$	$2\frac{1}{2}$
5	$2\frac{3}{8}$
$5\frac{1}{2}$	$2\frac{1}{4}$
6	

INTERNATIONAL (Metric)

Diameter in Millimetres.	Pitch in Millimetres.
6	1
7	1
8	1·25
9	1·25
10	1·5
11	1·5
12	1·75
14	2
16	2
18	2·5
20	2·5
22	2·5
24	3
27	3
30	3·5
33	3·5
36	4
39	4
42	4·5
45	4·5
48	5
52	5
56	5·5
60	5·5
64	6
68	6
72	6·5
76	6·5
80	7

B.A. SCREW THREADS (British Association)

No.	Diameter in Inches.	No. of Threads per Inch.
0	·236	25·4
1	·209	28·2
2	·185	31·4
3	·161	34·8
4	·142	38·5
5	·126	43
6	·110	47·9
7	·098	52·9
8	·087	59·1
9	·075	65·1
10	·067	72·6
11	·059	81·9
12	·051	90·7

BRITISH STANDARD KEYS

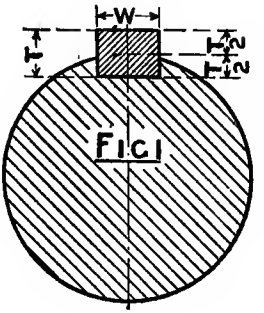


FIG I

	Diameter of Shaft in Inches.		Section of Key in Inches.	
	Over	To	W.	T.
1	1·25	1·50	·375	·250
2	1·50	2·00	·500	·375
3	2·00	2·50	·625	·4375
4	2·50	3·00	·750	·500
5	3·00	3·50	·875	·625
6	3·50	4·00	1·000	·6875
7	4·00	5·00	1·250	·8125
8	5·00	6·00	1·500	1·000
9	6·00	7·00	1·750	1·1875
10	7·00	8·00	2·000	1·375
11	8·00	10·00	2·500	1·625
12	10·00	12·00	3·000	2·000

NOTE.—The list of keys is reproduced by permission of the British Engineering Standards Association from their Report, No. 46.

AVERAGE WEIGHTS OF MATERIALS IN LBS. PER CUBIC INCH

Wrought Iron	·280
Cast Iron	·265
Steel (mild)	·284
Copper (sheet)	·320
Brass (cast)	·296
Lead	·411
Zinc	·260
Aluminium	·096
Muntz Metal	·296
Gun Metal	·315
Tin	·268
Phosphor Bronze	·300
Aluminium „	·273

IMPERIAL STANDARD WIRE GAUGE (I.W.G. or S.W.G.)

No.	Diameter in Inches.	No.	Diameter in Inches.
7/0	·5	23	·024
6/0	·464	24	·022
5/0	·432	25	·020
4/0	·4	26	·018
3/0	·372	27	·0164
2/0	·348	28	·0148
0	·324	29	·0136
1	·300	30	·0124
2	·276	31	·0116
3	·252	32	·0108
4	·232	33	·0100
5	·212	34	·0092
6	·192	35	·0084
7	·176	36	·0076
8	·160	37	·0068
9	·144	38	·0060
10	·128	39	·0052
11	·116	40	·0048
12	·104	41	·0044
13	·092	42	·0040
14	·080	43	·0036
15	·072	44	·0032
16	·064	45	·0028
17	·056	46	·0024
18	·048	47	·0020
19	·040	48	·0016
20	·036	49	·0012
21	·032	50	·0010
22	·028		

BIRMINGHAM WIRE GAUGE (B.W.G.)

No.	Diameter in Inches.	No.	Diameter in Inches.
0000	·454	17	·058
000	·425	18	·049
00	·380	19	·042
0	·340	20	·035
1	·300	21	·032
2	·284	22	·028
3	·259	23	·025
4	·238	24	·022
5	·220	25	·020
6	·203	26	·018
7	·180	27	·016
8	·165	28	·014
9	·148	29	·013
10	·134	30	·012
11	·120	31	·010
12	·109	32	·009
13	·095	33	·008
14	·083	34	·007
15	·072	35	·005
16	·065	36	·004

DECIMAL EQUIVALENTS OF FRACTIONAL PARTS OF AN INCH

Fractions.	Decimals.	Fractions.	Decimals.	Fractions.	Decimals.	Fractions.	Decimals.
$\frac{1}{64}$	·015625	$\frac{17}{64}$	·265625	$\frac{33}{64}$	·515625	$\frac{49}{64}$	·765625
$\frac{1}{32}$	·03125	$\frac{9}{32}$	·28125	$\frac{17}{32}$	·53125	$\frac{25}{32}$	·78125
$\frac{3}{64}$	·046875	$\frac{19}{64}$	·296875	$\frac{35}{64}$	·546875	$\frac{51}{64}$	·796875
$\frac{1}{16}$	·0625	$\frac{5}{16}$	·3125	$\frac{9}{16}$	·5625	$\frac{13}{16}$	·8125
$\frac{5}{64}$	·078125	$\frac{21}{64}$	·328125	$\frac{37}{64}$	·578125	$\frac{53}{64}$	·828125
$\frac{3}{32}$	·09375	$\frac{11}{32}$	·34375	$\frac{19}{32}$	·59375	$\frac{27}{32}$	·84375
$\frac{7}{64}$	·109375	$\frac{23}{64}$	·359375	$\frac{39}{64}$	·609375	$\frac{55}{64}$	·859375
$\frac{1}{8}$	·125	$\frac{3}{8}$	·375	$\frac{5}{8}$	·625	$\frac{7}{8}$	·875
$\frac{9}{64}$	·140625	$\frac{25}{64}$	·390625	$\frac{41}{64}$	·640625	$\frac{57}{64}$	·890625
$\frac{5}{32}$	·15625	$\frac{13}{32}$	·40625	$\frac{21}{32}$	·65625	$\frac{29}{32}$	·90625
$\frac{11}{64}$	·171875	$\frac{27}{64}$	·421875	$\frac{43}{64}$	·671875	$\frac{59}{64}$	·921875
$\frac{3}{16}$	·1875	$\frac{7}{16}$	·4375	$\frac{11}{16}$	·6875	$\frac{15}{16}$	·9375
$\frac{13}{64}$	·203125	$\frac{29}{64}$	·453125	$\frac{45}{64}$	·703125	$\frac{61}{64}$	·953125
$\frac{7}{32}$	·21875	$\frac{15}{32}$	·46875	$\frac{23}{32}$	·71875	$\frac{31}{32}$	·96875
$\frac{15}{64}$	·234375	$\frac{31}{64}$	·484375	$\frac{47}{64}$	·734375	$\frac{63}{64}$	·984375
$\frac{1}{4}$	·25	$\frac{1}{2}$	·5	$\frac{3}{4}$	·75	1	1·0

METRICAL TABLE WITH ENGLISH EQUIVALENTS TO THE NEAREST THIRTY-SECOND OF AN INCH

Mm.	Ins.	Mm.	Ins.	Mm.	Ins.	Mm.	Ins.	Mm.	Ins.
1 =	$\frac{5}{128}$	29 =	$1\frac{5}{32}$	57 =	$2\frac{1}{4}$	85 =	$3\frac{11}{32}$	325 =	$12\frac{25}{32}$
2 =	$\frac{5}{64}$	30 =	$1\frac{3}{16}$	58 =	$2\frac{9}{32}$	86 =	$3\frac{3}{8}$	350 =	$13\frac{25}{32}$
3 =	$\frac{1}{8}$	31 =	$1\frac{7}{32}$	59 =	$2\frac{5}{16}$	87 =	$3\frac{7}{16}$	375 =	$14\frac{3}{4}$
4 =	$\frac{5}{32}$	32 =	$1\frac{1}{4}$	60 =	$2\frac{3}{8}$	88 =	$3\frac{15}{32}$	400 =	$15\frac{3}{4}$
5 =	$\frac{3}{16}$	33 =	$1\frac{3}{16}$	61 =	$2\frac{13}{32}$	89 =	$3\frac{1}{2}$	425 =	$16\frac{23}{32}$
6 =	$\frac{1}{4}$	34 =	$1\frac{11}{32}$	62 =	$2\frac{7}{16}$	90 =	$3\frac{17}{32}$	450 =	$17\frac{23}{32}$
7 =	$\frac{9}{32}$	35 =	$1\frac{3}{8}$	63 =	$2\frac{15}{32}$	91 =	$3\frac{9}{16}$	475 =	$18\frac{11}{16}$
8 =	$\frac{5}{16}$	36 =	$1\frac{13}{32}$	64 =	$2\frac{17}{32}$	92 =	$3\frac{5}{8}$	500 =	$19\frac{11}{16}$
9 =	$\frac{11}{32}$	37 =	$1\frac{15}{32}$	65 =	$2\frac{9}{16}$	93 =	$3\frac{21}{32}$	525 =	$20\frac{21}{32}$
10 =	$\frac{13}{32}$	38 =	$1\frac{1}{2}$	66 =	$2\frac{19}{32}$	94 =	$3\frac{11}{16}$	550 =	$21\frac{21}{32}$
11 =	$\frac{7}{16}$	39 =	$1\frac{17}{32}$	67 =	$2\frac{5}{8}$	95 =	$3\frac{3}{4}$	575 =	$22\frac{5}{8}$
12 =	$\frac{15}{32}$	40 =	$1\frac{9}{16}$	68 =	$2\frac{21}{32}$	96 =	$3\frac{25}{32}$	600 =	$23\frac{5}{8}$
13 =	$\frac{1}{2}$	41 =	$1\frac{5}{8}$	69 =	$2\frac{23}{32}$	97 =	$3\frac{13}{16}$	625 =	$24\frac{19}{32}$
14 =	$\frac{9}{16}$	42 =	$1\frac{21}{32}$	70 =	$2\frac{3}{4}$	98 =	$3\frac{27}{32}$	650 =	$25\frac{19}{32}$
15 =	$\frac{19}{32}$	43 =	$1\frac{11}{16}$	71 =	$2\frac{25}{32}$	99 =	$3\frac{29}{32}$	675 =	$26\frac{9}{16}$
16 =	$\frac{5}{8}$	44 =	$1\frac{23}{32}$	72 =	$2\frac{27}{32}$	100 =	$3\frac{15}{16}$	700 =	$27\frac{9}{16}$
17 =	$\frac{21}{32}$	45 =	$1\frac{25}{32}$	73 =	$2\frac{7}{8}$	105 =	$4\frac{1}{8}$	725 =	$28\frac{17}{32}$
18 =	$\frac{23}{32}$	46 =	$1\frac{13}{16}$	74 =	$2\frac{29}{32}$	110 =	$4\frac{11}{32}$	750 =	$29\frac{17}{32}$
19 =	$\frac{3}{4}$	47 =	$1\frac{27}{32}$	75 =	$2\frac{15}{16}$	115 =	$4\frac{17}{32}$	775 =	$30\frac{1}{2}$
20 =	$\frac{25}{32}$	48 =	$1\frac{7}{8}$	76 =	3	120 =	$4\frac{23}{32}$	800 =	$31\frac{1}{2}$
21 =	$\frac{13}{16}$	49 =	$1\frac{15}{16}$	77 =	$3\frac{1}{32}$	125 =	$4\frac{29}{32}$	825 =	$32\frac{15}{32}$
22 =	$\frac{7}{8}$	50 =	$1\frac{31}{32}$	78 =	$3\frac{1}{16}$	150 =	$5\frac{29}{32}$	850 =	$33\frac{15}{32}$
23 =	$\frac{29}{32}$	51 =	2	79 =	$3\frac{1}{8}$	175 =	$6\frac{7}{8}$	875 =	$34\frac{7}{16}$
24 =	$\frac{15}{16}$	52 =	$2\frac{1}{16}$	80 =	$3\frac{5}{32}$	200 =	$7\frac{7}{8}$	900 =	$35\frac{7}{16}$
25 =	$\frac{31}{32}$	53 =	$2\frac{3}{32}$	81 =	$3\frac{3}{16}$	225 =	$8\frac{27}{32}$	925 =	$36\frac{13}{32}$
26 =	$1\frac{1}{32}$	54 =	$2\frac{1}{8}$	82 =	$3\frac{7}{32}$	250 =	$9\frac{27}{32}$	950 =	$37\frac{13}{32}$
27 =	$1\frac{1}{16}$	55 =	$2\frac{5}{32}$	83 =	$3\frac{9}{32}$	275 =	$10\frac{13}{16}$	975 =	$38\frac{3}{8}$
28 =	$1\frac{3}{32}$	56 =	$2\frac{7}{32}$	84 =	$3\frac{5}{16}$	300 =	$11\frac{13}{16}$	1000 =	$39\frac{3}{8}$

INDEX TO EXAMPLES

In Examples marked **A** detailed working drawings require to be made from illustrations which show the parts assembled together.

In Examples marked **B** assembly or arrangement drawings require to be made. In these cases the illustrations show either each detail separately, or assembly views other than those illustrated are called for.

In Examples marked **C** working drawings of designs similar to those illustrated are required, but the student is instructed to work to modified dimensions.

Examples marked **D** are usually geometrical constructions.

Examples marked **E** are tracing examples.

	Example.	Page.	
Aeroplane Engine Air Pump	78	110	A
,, ,, ,,	79	110	B
,, ,, Cylinder, etc.	76	107	A
,, ,, ,,	77	107	E
,, ,, Oil Pump	80	114	A
,, ,, ,,	81	114	B
,, ,, Propeller Hub	75	105	A
Armature for Continuous Current Generator	89	133	A
,, ,, ,, ,, ,,	90	133	C
Ball-bearing and Hanger	10	15	B
,, ,, ,,	11	15	E
Ball Thrust Bearing	32	45	C
Base Plate for Steam Hammer	152	217	A
Bearing, Collar Thrust	12	17	A
,, ,, ,,	13	17	C
,, and End Frame (induction motor)	101	145	A
,, ,, ,, Details	102	145	C
,, ,, ,, ,,	103	145	B
,, ,, ,,	104	145	E
,, for Mine Fan	9	13	B
,, Pedestal for Dynamo	93	137	A
,, ,, ,,	94	137	C
,, ,, ,,	95	137	E
Bed for Ending Lathe	133	181	A
,, Pipe-screwing Machine	139	191	A
,, Hydraulic Capstan	118	163	A
Bevel Gearing	27	41	C
Block for 10-Ton Crane	14	19	A
,, 15 ,,	15	19	C
,, 10 ,,	16	19	E
,, 40 ,,	17	22	A
,, 40 ,,	18	22	B
Boiler Fire-box (traction engine)	71	93	A
,, Marine Type	72	95	A
,, Details (Suckling water tube)	73	101	C

	Example.	Page.	
Boiler Safety Valves (Ramsbottom)	69	91	B
,, ,, ,,	70	91	E
,, Scum Cock	67	89	A
,, ,, ,,	68	89	B
,, Shell (Suckling water tube)	74	101	A
Broad Flange Beam Stanchion	19	25	B
Brush Holder for Continuous Current Generator	96	139	B
,, ,, Induction Motor	105	147	A
,, ,, ,, ,,	106	147	C
Capstan, Hydraulic	117	161	B
,, Bed	118	163	A
,, Crank Shaft, etc.	120	167	A
,, Cylinders, etc.	122	169	A
,, ,, Carriers, etc.	123	169	A
,, Levers, etc.	121	167	A
,, Revolving Plate and Bollard	119	165	A
,, Unions	129	173	C
,, Valves	124	171	A
,, ,,	125	171	B
,, ,,	126	171	B
,, ,,	127	171	E
,, Water Cock	128	173	C
Casing for Sirocco Fan	7	11	A
,, ,, ,,	8	11	E
Clutch (cone) for Motor Car	82	118	A
,, (plate) Benn	3	6	A
,, ,, ,,	4	6	C
,, ,, ,,	5	6	E
Cock (scum) for Locomotive Boiler	67	89	A
,, ,, ,, ,,	68	89	B
Collar Thrust Bearing	12	17	A
,, ,,	13	17	C
Colliery Head Gear Pulley	6	9	B
Commutator for Continuous Current Generator	91	135	A
,, ,, ,, ,,	92	135	C
Connecting Rod High-speed Steam Engine	46	63	A
Coupling (flexible)	1	3	A
,, ,,	2	3	C
Crane Block, 10-Ton	14	19	A
,, ,, 15 ,,	15	19	C
,, ,,	16	19	E
,, ,, 40-Ton	17	22	A
,, ,, ,,	18	22	B
Crank Shaft for Hydraulic Capstan	120	167	A
Cross-head, Locomotive, Two Bar	39	55	A
,, ,, Single Bar	41	57	B
,, Oil-box	40	55	C
Curves, Cycloidal	20	32	D
,, Involute	22	35	D
Cycloidal Teeth for Gear Wheels	21	32	D
Cylinders, Aeroplane Engine	76	107	A
,, Hydraulic Capstan	122	169	A
,, Traction Engine	49	67	B
,, Steam Hammer	155	222	A
,, ,, ,,	157	222	E
,, Carrier (capstan)	123	169	B
,, Covers (traction engine)	52	71	C
,, ,, (traction engine steam chest)	53	71	C
,, ,, ,, ,,	54	71	E

	Example.	Page.	
Drilling Jig for Gear-box	150	211	B
,, ,, Shell Noses	149	209	B
Dynamo Armature	89	133	A
,, ,,	90	133	C
,, Bearing (pedestal)	93	137	A
,, ,, ,,	94	137	C
,, ,, ,,	95	137	E
,, Brush Holder	96	139	B
,, Commutator	91	135	A
,, ,,	92	135	C
,, Field Frame	86	130	A
,, ,, ,,	88	130	B
,, Pole Shoes	87	130	A
Eccentric and Rod for High-speed Steam Engine	47	65	B
,, ,, ,, ,, ,,	48	65	E
End Frame and Bearing for Induction Motor	101	145	A
,, ,, Details	102	145	C
,, ,,	103	145	B
,, ,,	104	145	E
Ending Lathe, General Arrangement	130	177	B
,, ,, Bed	133	181	A
,, ,, Saddle	134	183	A
,, ,, Spindle, etc.	135	185	A
,, ,, ,, ,,	136	185	E
,, ,, Stands	131	179	A
,, ,, ,,	132	179	E
Fan Bearing, Mine	9	13	B
,, Housing, Sirocco	7	11	A
,, ,, ,,	8	11	E
Field Frame for Dynamo	86	130	A
,, ,, ,,	88	130	B
Fire-box for Traction Engine Boiler	71	93	A
Flexible Coupling	1	3	A
,, ,,	2	3	C
Gearing, Bevel	27	41	C
,, Helical	28	43	A
,, ,,	29	43	B
,, Housing for Worm	33	47	A
,, ,, ,,	34	47	B
,, ,, ,,	35	47	E
,, for Motor Car	83	122	A
,, Internal	26	39	C
,, Worm	30	45	A
,, ,,	31	45	C
Gear Wheels, Small	24	37	C
,, ,, Large	25	37	C
,, ,, Teeth of, Cycloidal	21	32	D
,, ,, ,, Involute	23	35	D
Gnome Engine Cylinder, etc.	76	107	A
Governor, Steam Engine, "Pickering"	56	75	A
,, ,, ,,	57	75	B
,, ,, ,,	58	77	A
,, ,, ,,	59	77	E
,, ,, ,,	60	77	B

	Example.	Page.	
Governor, Steam Turbine	61	81	A
,, ,, ,,	62	82	E
,, ,, ,,	63	83	A
Guide for Valve Rod (locomotive)	36	51	B
,, ,, ,,	37	52	C
,, ,, ,,	38	52	E
Hanger with Ball-bearing	10	15	B
,, ,, ,,	11	15	E
Head Gear Pulley (colliery)	6	9	B
Helical Gearing	28	43	A
,, ,,	29	43	B
High-speed Steam Engine Connecting Rod	46	63	A
,, ,, ,, Eccentric	47	65	B
,, ,, ,, ,,	48	65	E
Housing for Worm Gear	33	47	A
,, and Worm Gear	34	47	B
,, ,, ,,	35	47	E
Hub for Aeroplane Propeller	75	105	A
Hydraulic Capstan, General Arrangement	117	161	B
,, ,, Bed	118	163	A
,, ,, Carriers for Cylinders	123	169	B
,, ,, Crank Shaft, etc.	120	167	A
,, ,, Cylinders, etc.	122	169	A
,, ,, Levers, etc.	121	167	A
,, ,, Revolving Plate	119	165	A
,, ,, Unions	129	173	C
,, ,, Valves	124	171	A
,, ,, ,,	125	171	B
,, ,, ,,	126	171	B
,, ,, ,,	127	171	E
,, ,, Water Cock	128	173	C
,, Press (200 tons)	110	153	A
,, ,, ,,	111	153	B
,, ,, ,,	112	155	A
,, Pump	113	157	A
,, ,,	114	157	B
,, ,,	115	159	A
,, ,,	116	159	E
,, Stop Valve	107	151	A
,, ,, ,,	108	151	C
,, ,, ,,	109	151	E
Induction Motor, Brush Holder	103	145	A
,, ,, ,,	104	145	C
,, ,, End Frame and Bearing	101	145	A
,, ,, ,, Details	102	145	C
,, ,, ,, ,,	103	145	B
,, ,, ,, ,,	104	145	E
,, ,, Rotor	99	143	A
,, ,, ,,	100	143	B
,, ,, Stator	97	141	A
,, ,, ,,	98	141	B
Internal Gearing	26	39	C
Involute Curve Construction	22	35	D
,, Teeth for Gear Wheels	23	35	D
Jig for Drilling Gear Case	150	211	B
,, ,, Shell Noses	149	209	B

	Example.	Page.	
Lathe, Shell-ending, Arrangement	130	177	B
,, ,, Bed	133	181	A
,, ,, Saddle	134	183	A
,, ,, Spindle, etc.	135	185	A
,, ,, ,,	136	185	E
,, ,, Stands, etc.	131	179	A
,, ,, ,,	132	179	E
,, Square Turret for	137	187	B
Levers for Hydraulic Capstan	121	167	A
Locomotive Cross-head, Two Bar	39	55	A
,, ,, Single Bar	41	57	B
,, Cylinder Cover	42	59	A
,, ,, ,,	43	59	C
,, ,, ,,	44	59	E
,, Safety Valves (Ramsbottom)	69	91	B
,, ,, ,,	70	91	E
,, Scum Cock for Boiler	67	89	A
,, ,, ,,	68	89	B
,, Steam Regulator	45	61	B
,, Valve Rod Guide	36	51	B
,, ,, ,,	37	52	C
,, ,, ,,	38	52	E
Metallic Packing for Cylinder Cover	42	59	A
,, ,, ,, ,,	43	59	C
,, ,, ,, ,,	44	59	E
Mine Fan Bearing	9	13	B
Motor Car Clutch	82	118	A
,, ,, Gearing	83	122	A
,, ,, Calculation	84	122	—
,, Omnibus Steering Gear	85	125	A
,, (induction) Brush Holder	105	147	A
,, ,, ,, ,,	106	147	C
,, ,, End Frame and Bearing	101	145	A
,, ,, ,, Details	102	145	C
,, ,, ,, ,,	103	145	B
,, ,, ,, ,,	104	145	E
,, ,, Rotor	99	143	A
,, ,, ,,	100	143	B
,, ,, Stator	97	141	A
,, ,, ,,	98	141	B
Oil-box for Locomotive Cross-head	40	55	C
Oil pump for Aeroplane Engine	80	114	A
,, ,, ,, ,,	81	114	B
Packing, Metallic, for Cylinder Cover	42	59	A
,, ,, ,, ,, ,,	43	59	C
,, ,, ,, ,, ,,	44	59	E
Pedestal Bearing for Dynamo	93	137	A
,, ,, ,, ,,	94	137	C
,, ,, ,, ,,	95	137	E
Pickering Governor for Steam Engine	56	75	A
,, ,, ,, ,,	57	75	B
,, ,, ,, ,,	58	77	A
,, ,, ,, ,,	59	77	E
,, ,, ,, ,,	60	79	B
Pipe-screwing Machine Arrangement	138	189	B
,, ,, Bed	139	191	A

	Example.	Page.	
Pipe-Screwing Machine Driving Gear	140	191	B
,, ,, ,,	147	205	A
,, ,, Leading Screw, etc.	146	203	A
,, ,, Saddle	142	197	B
,, ,, Stands, etc.	148	207	A
,, ,, Star Wheel	143	197	C
,, ,, Tool Holder	145	201	A
,, ,, Turning Head	144	199	A
,, ,, Worm Gear	141	193	B
Piston, Aeroplane Engine	76	107	A
,, Traction Engine	51	69	C
Plate Clutch (Benn)	3	6	A
,, ,,	4	6	C
,, ,,	5	6	E
Pole Shoe for Dynamo	87	130	A
Press, Hydraulic	110	153	A
,, ,,	111	153	B
,, ,,	112	155	A
Propeller Hub (aeroplane)	75	105	A
Pulley, Colliery Head Gear	6	9	B
Pump, Air, for Aeroplane Engine	78	110	A
,, ,, ,, ,,	79	110	B
,, Hydraulic	113	157	A
,, ,,	114	157	B
,, ,,	115	159	A
,, ,,	116	159	E
,, Oil, for Aeroplane Engine	80	114	A
,, ,, ,, ,, ,,	81	114	B
Ramsbottom Safety Valves	69	91	B
,, ,,	70	91	E
Regulator, Steam	45	61	B
Revolving Plate for Hydraulic Capstan	119	165	A
Rod, Connecting, High-speed Steam Engine	46	63	A
,, Guide, Valve	36	51	B
,, ,, ,,	37	52	C
,, ,, ,,	38	52	E
Rotor for Induction Motor	99	143	A
,, ,, ,,	100	143	B
Saddle for Ending Lathe	134	183	A
Safety Valves, Ramsbottom	69	91	B
,, ,,	70	91	E
Screwing Machine (pipe) Arrangement	138	189	B
,, ,, ,, Bed	139	191	A
,, ,, ,, Driving Gear	140	191	B
,, ,, ,, ,,	147	205	A
,, ,, ,, Leading Screw, etc.	146	203	A
,, ,, ,, Saddle	142	197	B
,, ,, ,, Stands, etc.	148	207	A
,, ,, ,, Star Wheel	143	197	C
,, ,, ,, Tool Holder	145	201	A
,, ,, ,, Turning Head	144	199	A
,, ,, ,, Worm Gear	141	193	B
Scum Cock for Locomotive Boiler	67	89	A
,, ,, ,, ,,	68	89	B
Shell-ending Lathe Arrangement	130	177	B
,, ,, Bed	133	181	A
,, ,, Saddle	134	183	A

	Example.	Page.	
Shell-ending Lathe Spindle, etc.	135	185	A
,, ,, ,, ,,	136	185	E
,, ,, Stands, etc.	131	179	A
,, ,, ,,	132	179	E
Sirocco Fan Housing	7	11	A
,, ,, ,,	8	11	E
Slide Valves, Traction Engine	50	69	C
Square Turret for Lathe	137	187	B
Stanchion	19	25	B
Stator for Induction Motor	97	141	A
,, ,, ,,	98	141	B
Steam Hammer Assembly	151	215	B
,, ,, Base Plate	152	217	A
,, ,, Cylinders and Valves	155	222	A
,, ,, ,,	157	222	E
,, ,, Standards	153	219	A
,, ,, ,,	154	219	E
,, ,, Stop Valve	156	222	A
Steering Gear for Motor Omnibus	85	125	A
Stop Valve, Hydraulic	107	151	A
,, ,,	108	151	C
,, ,,	109	151	E
,, Steam	64	87	B
,, ,,	65	87	C
,, ,,	66	87	E
Teeth of Gear Wheels, Cycloidal	21	32	D
,, ,, Involute	23	35	D
Thrust Bearing, Ball	32	45	C
,, ,, Collar	12	17	A
,, ,, ,,	13	17	C
Toothed Gear Wheel (small)	24	37	C
,, ,, (large)	25	37	C
Traction Engine Cylinders	49	67	B
,, ,, Cylinder Covers	52	71	C
,, ,, Fire-box	71	93	A
,, ,, Piston	51	69	C
,, ,, Slide Valves	50	69	C
,, ,, Steam Chest Covers	53	71	C
,, ,, ,, ,,	54	71	E
,, ,, Stuffing Box	55	73	C
Turbine Governor	61	81	A
,, ,,	62	81	E
,, ,,	63	83	A
Turret for Lathe	137	187	B
Unions for Hydraulic Capstan	129	173	C
Valves for Hydraulic Capstan	124	171	A
,, ,, ,,	125	171	B
,, ,, ,,	126	171	B
,, ,, ,,	127	171	E
Valve, Hydraulic Stop	107	151	A
,, ,, ,,	108	151	C
,, ,, ,,	109	151	E
,, Rod Guide (locomotive)	36	51	B
,, ,, ,,	37	52	C
,, ,, ,,	38	52	E

	Example.	Page.	
Valve, Ramsbottom Safety	69	91	B
,, ,, ,,	70	91	E
,, Slide, for Traction Engine	50	69	C
,, Steam Stop	64	87	B
,, ,, ,,	65	87	C
,, ,, ,,	66	87	E
,, ,, ,, (for steam hammer)	156	222	A
Water Cock for Hydraulic Capstan	128	173	C
,, Tube Boiler (Suckling) Details	73	101	C
,, ,, ,, Shell	74	101	A
Wheel, Small Gear	24	37	C
,, Large Gear	25	37	C
,, Teeth, Cycloidal	21	32	D
,, ,, Involute	23	35	D
Worm Gearing for Hoist	30	45	A
,, ,, ,,	31	45	C
,, ,, Housing	33	47	A
,, ,, and Housing	34	47	B
,, ,, ,,	35	47	E
,, ,, for Pipe-screwing Machine	141	193	B

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